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Mobile Communications Network Architecture (MCNA) Final Briefing August 15th, 2005

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Co-Funded by FAA and NASA GRC under the Boeing Global Communication, Navigation and Surveillance System (GCNSS) Follow-on Contract

Boeing team includes: Boeing, Avaliant, Honeywell & ITT

Agenda

EST	1:00	Executive Summary & Overview	(0:25)	Messorole/Griep
	1:25	Requirements Analysis	(0:25)	Griep
	1:50	Architecture Analysis	(0:40)	Griep/Taylor/Roy
	2:30	Certification	(0:15)	LaBerge
	2:45	SED	(0:20)	Gilbert
	3:05	Break (0:15)		
	3:20	Transition Analysis	(0:20)	Griep
	3:40	Investment Analysis	(0:20)	Glickman/Griep
	4:00	Technology Gaps & Roadmap	(0:40)	Gilbert
	4:40	Conclusions and Recom.	(0:20)	Griep
	5:00	Questions/Adjourn		

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Executive Summary

Chip Meserole & Karl Griep
MCNA Final Briefing
15 August 2005

GCNSS Phase II Program

- **$13M program**
  - **September 2004 through August 2005**
  - **Systems Engineering**
    - **2 Iterations: Concept of Use, Requirements, Architecture, Business Case**
    - **Mobile Communication Network Architecture study (NASA Glenn)**
  - **Demonstrations**
    - **Develop SWIM Prototype, Testbed, & perform demonstrations**
- **$3.2M SWIM Extension (in review)**
  - **October 2005 through December 2005**
  - **Continue key Systems Engineering tasks supporting business case**
  - **Continue key Demonstrations tasks**
  - **Install node of SWIM Prototype in FAA HQ**
  - **Support traveling road shows**
- **$X MCNA Extension (in development)**

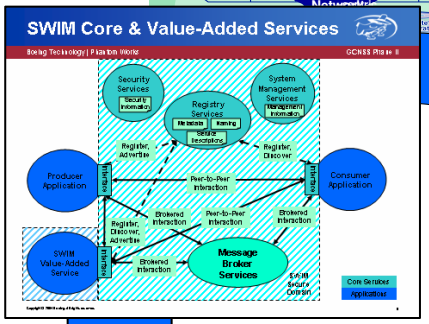
System Wide Information Management (SWIM)

- **Framework for network centric operations**
  - √ **Necessary enabler to NAS Transformation**
  - √ **Geographic independence of monitoring, command and control**
  - √ **Enable new levels of redundancy from currently installed systems**
  - √ **Data formats and architectures that readily enable new applications**
  - √ **Enable the sharing of inter-agency aviation security information**
- **Provides an Enterprise applications integration mechanism and an information connectivity strategy**
  - ✓ **Built on top of FTI network**
  - ✓ **Promotes platform convergence**

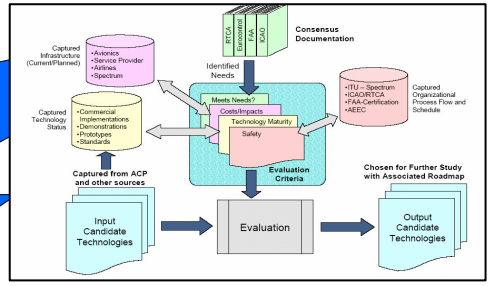
SWIM implements a modern, system-wide approach to information management necessary to support improved operations, productivity and national security in the NAS

MCNA Relationship with Past, Present & Future NASA Research Activities

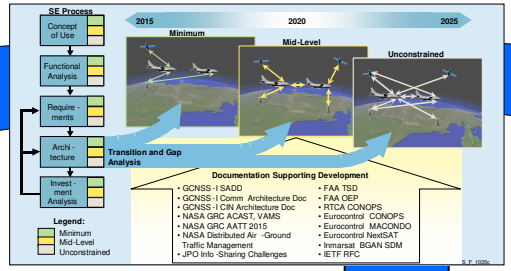
GCNSS- I
GCNSS- II



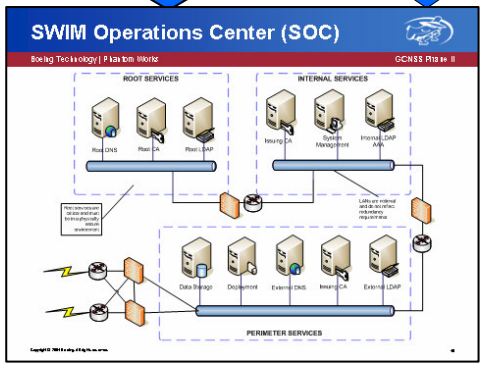
FAA/NASA
Future Communications Study



NASA/FAA
MCNA

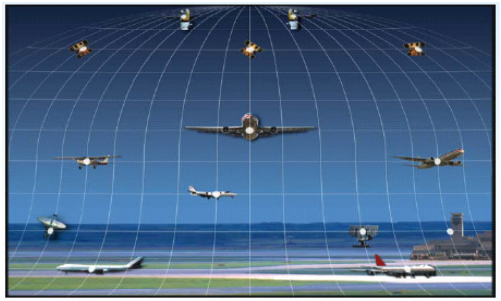


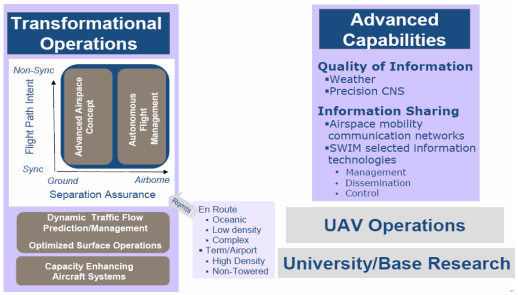
FAA
SWIM



NASA TNAS
2015-2025

NASA SBT
2007-2015





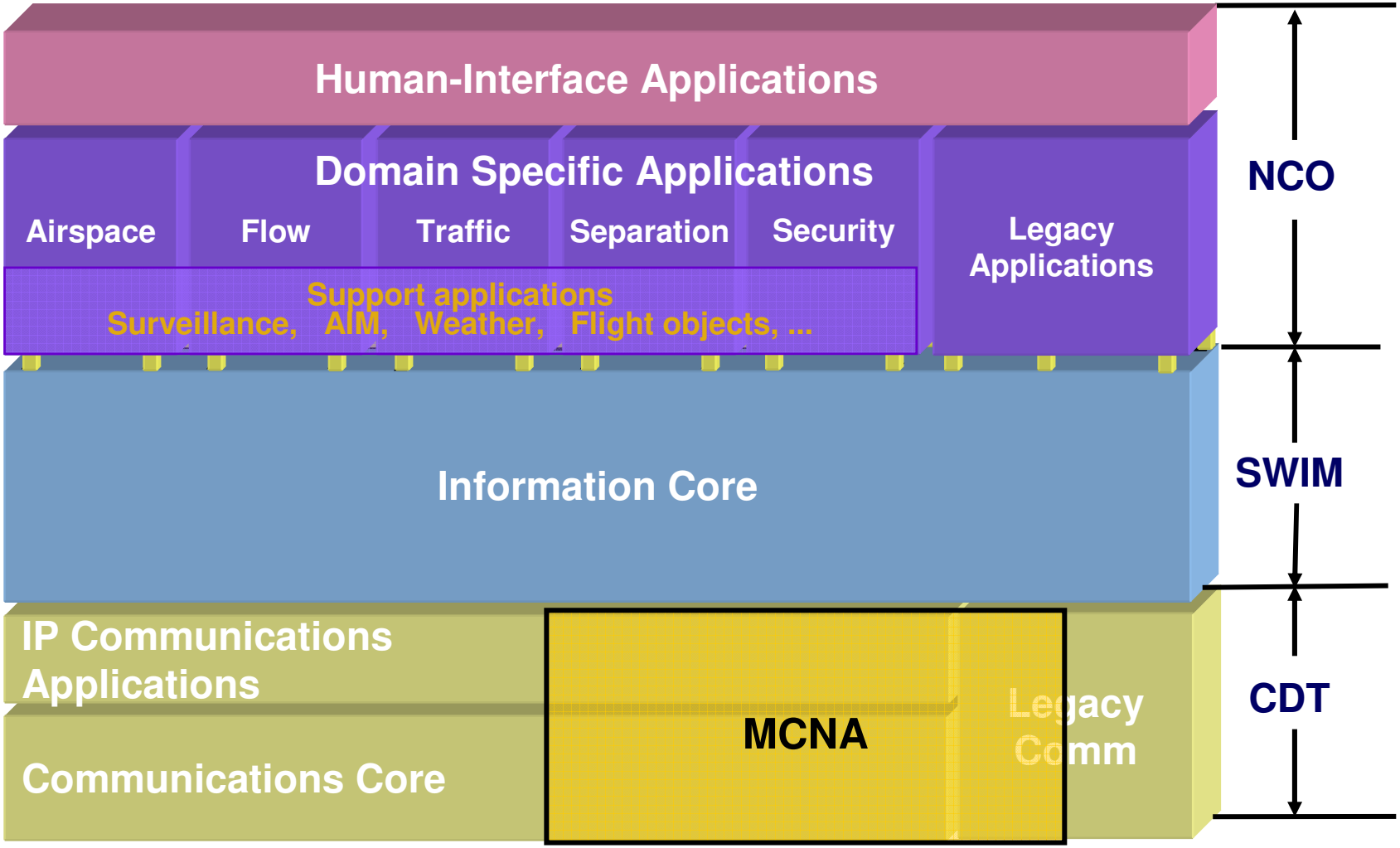
What is MCNA ?

- **The aggregate of all A-G and A-A voice and data communications for CNS/ATM**
  - **Includes physical and datalink aspects**
  - **Most concerned with internetworking considerations**
- **MCNA is a Methodology for integrating disparate A-G & A-A communications links into a coherent communication networking solution**
  - **Achieving aggressive service levels using two or more individual communication systems**
  - **Seamless service coverage across airspace domains and all aircraft classes**
- **This effort has specifically focused on communication support for Network Centric Operations**

MCNA and SWIM

- **MCNA will eventually become an extension of the Common Data Transport (CDT)**
  - **Extends SWIM to the aircraft**
- **Initial focus on datalink transition**
  - **Timelines for avionics upgrades**
  - **Coordination with ground infrastructure and procedures**
- **Early implementations of SWIM mobility may employ gateways/brokers on the aircraft and the ground**
  - **Store and distribute static SWIM information**
  - **Provide common information and communication interface to new applications on the aircraft**
- **As MCNA capabilities expand, certain aspects of SWIM may be extended directly to the aircraft**
  - **Real time collection and distribution of dynamic information**

Architecture Reference Model



Summary of Conclusions and Recommendations

- Comparison of ATN and MCNA
- Required Communication Performance (RCP)
- Common Links for Safety of Life and Non-Safety of Life Traffic
- Certification Process Enhancements
- Initiate Near Term Deployment of IP
- MCNA as a Transformational Approach

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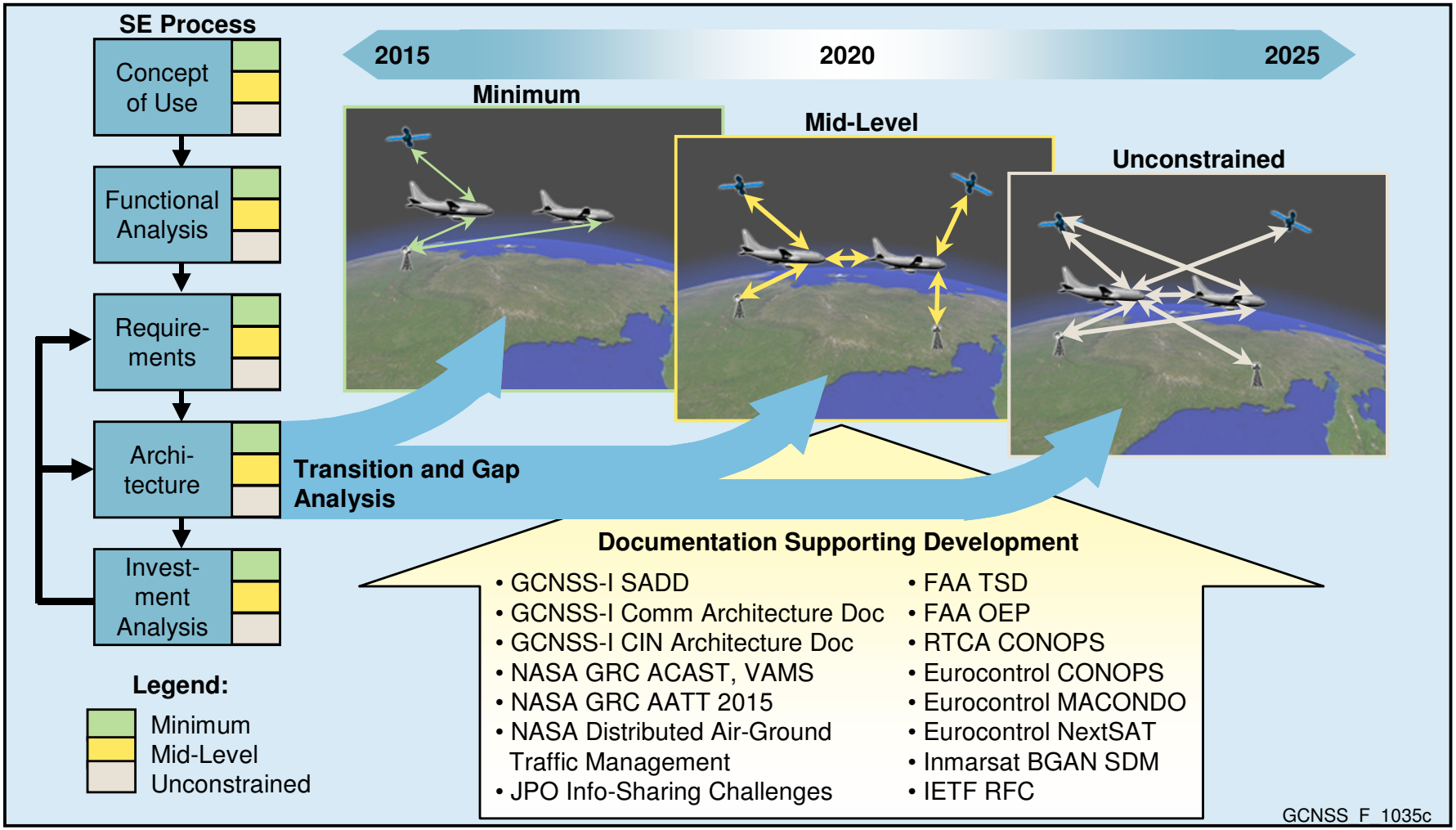
MCNA Task Overview

Karl Griep

MCNA Task Introduction

- System of System Engineering (SoSE) approach
  - Mission Needs and CoU
    - Defining a set of representative MCNA enabled scenarios
  - Functional Analysis
  - Requirements Definition
  - Architecture Development
    - Defining a representative set of communication services
  - Transition
    - Mapping services to scenarios
    - Mapping communication systems to services
  - Investment Analysis
- Small effort (relative to SWIM) with significant breadth

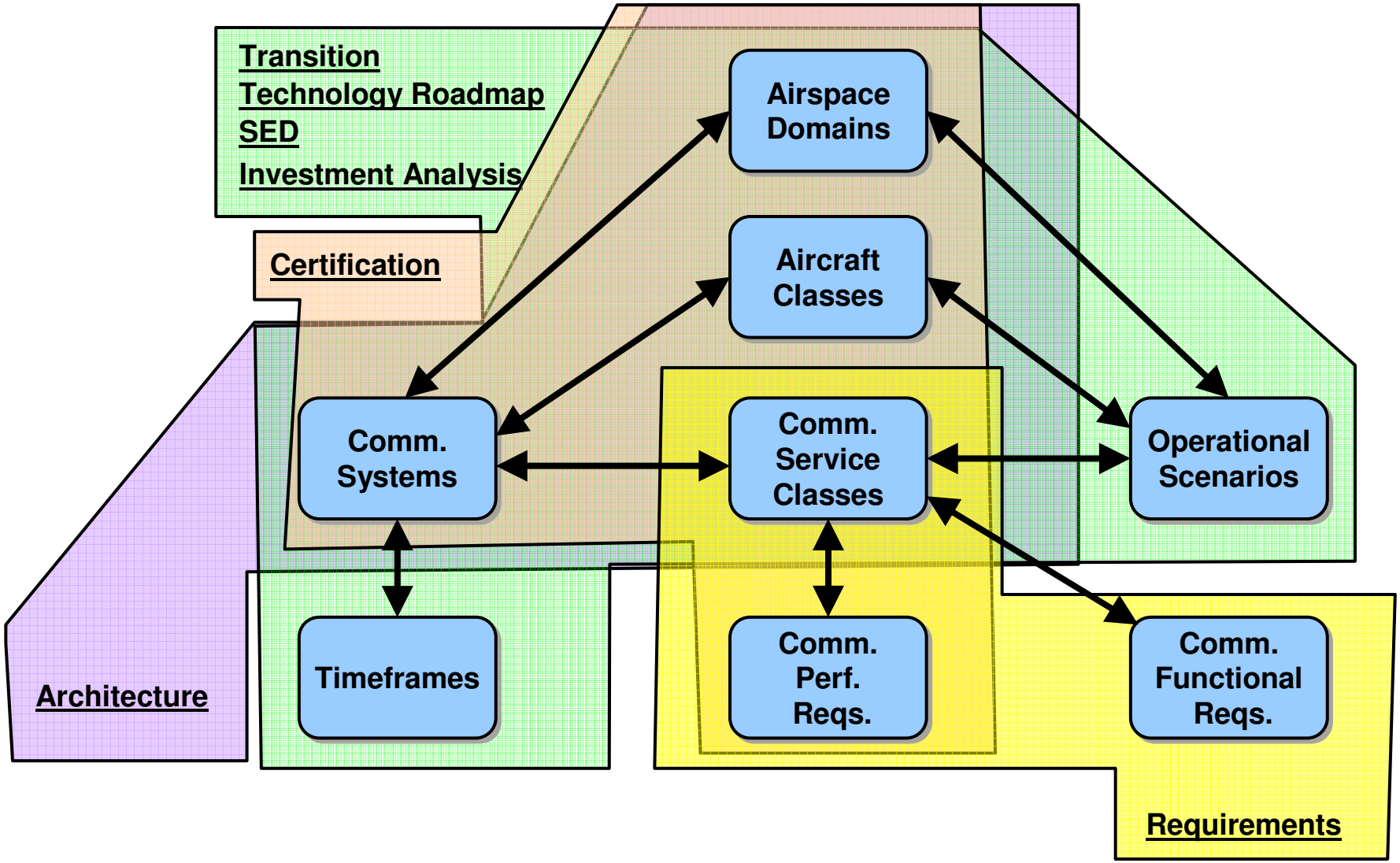
MCNA SoSE Approach



MCNA Subtasks

- Requirements
- Architecture
- Transition and Interoperability
- Simulation, Emulation and Demonstration (SED)
- Certification
- Investment Analysis
- Technology Gaps and Roadmap

MCNA Task Data Organization



MCNA Deliverables

CDRL	Name	Approximate Effort (Labor Months)	Approx. Pages
A046	MCNA Requirement Report	7	90
A040	MCNA Architecture Report	7	130
A042	Transition & Interoperability Report	4	60
A041	Technology Roadmap (Presentation)	2	25
A043	Simulation, Emulation, and Demonstration Report	2.5	80
A044	MCNA Investment Analysis Report	2	70
A047	Certification Plan Report	2	80
A045	MCNA Final Report	2.5	80
TOTAL		29	~600

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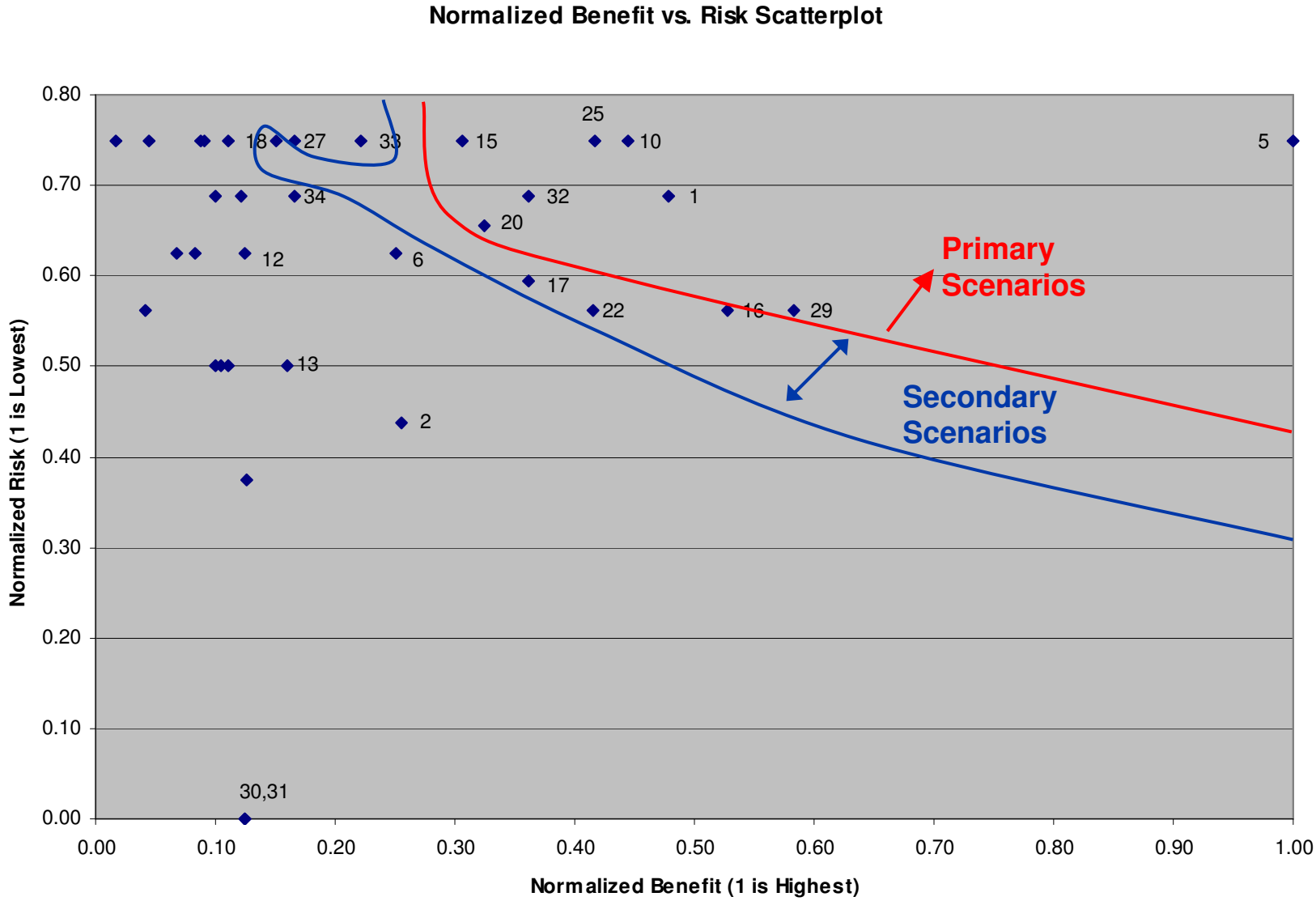
MCNA Requirements

Karl Griep
MCNA Final Briefing
15 August 2005

MCNA Operational Scenarios

- Broad survey of potential ATM scenarios that would be enhanced or enabled via MCNA
- Source Examples:
  - NAS 5.0 Operational Improvements (OI)
  - AATT RTO-24, MACONDO,
  - SWIM Investment Analysis
  - MCNA team brainstorming
- Produced 36 Unique MCNA Scenarios
  - Representative
  - Not exhaustive
- Down selected based on Benefit/Risk analysis based on multiple goodness equations
  - 8 Primary Scenarios
  - 4 Secondary Scenarios
  - 5 High Risk Scenarios

Operational Scenario Evaluation



Primary Operational Scenarios

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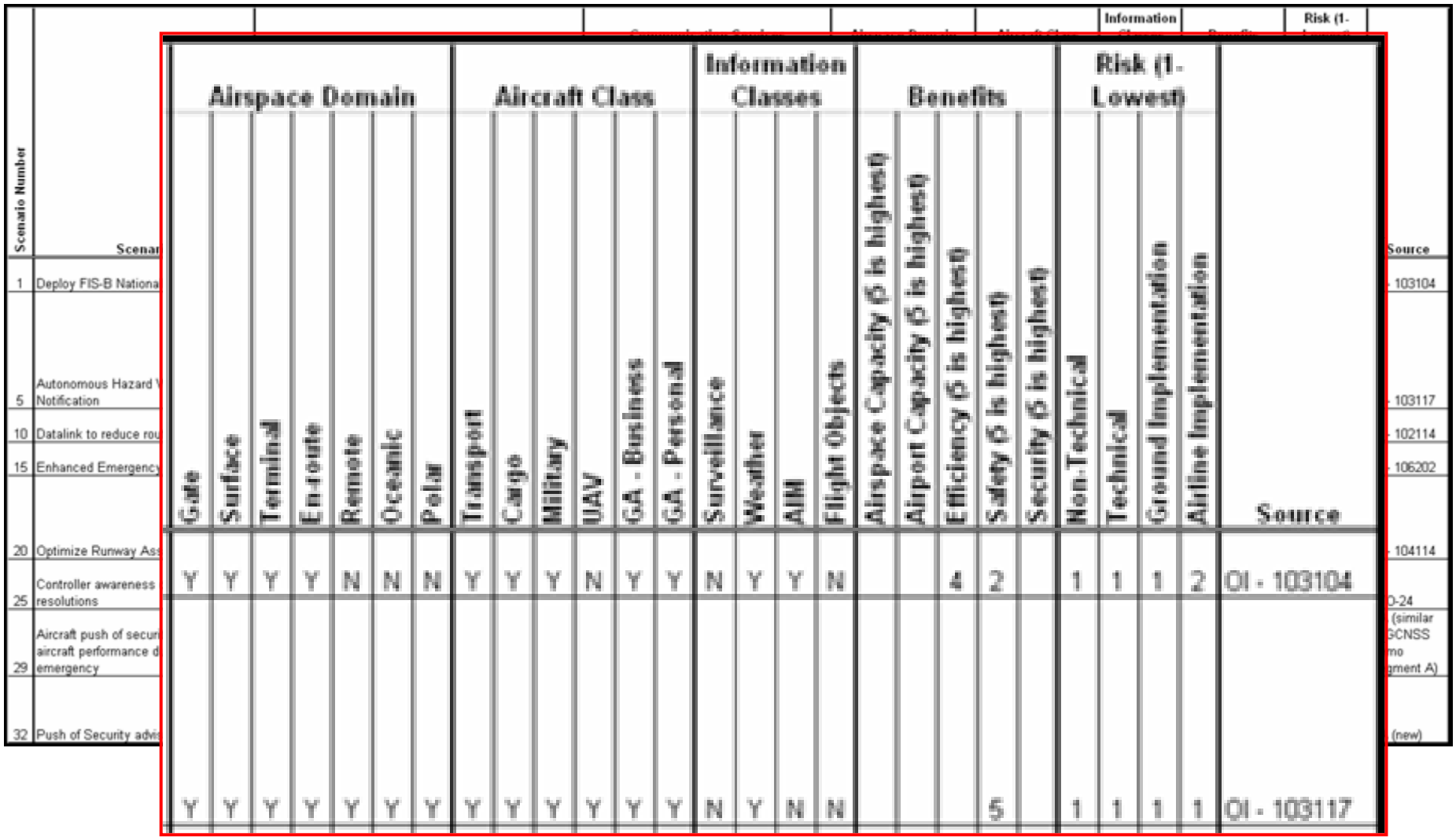
GCNSS Phase II

			Communication Services												Airspace Domain							Aircraft Class						Information Classes				Benefits					Risk (1-Lowest)				
Scenario Number	Scenario	Description	Party-line Voice	SA Voice	Broadcast Voice	Data Messaging	Tojaectory exchange	Broadcast to Aircraft	Broadcast From Aircraft	Ground to Air Data	Ground to Ground Data	Air to Ground Data	Air to Air Data	Video Exchange	Vehicle Command and Control	Gate	Surface	Terminal	En-route	Remote	Oceanic	Polar	Transport	Cargo	Military	UAV	GA - Business	GA - Personal	Surveillance	Weather	AIM	Flight Objects	Airspace Capacity (5 is highest)	Airport Capacity (5 is highest)	Efficiency (5 is highest)	Safety (5 is highest)	Security (5 is highest)	Non-Technical	Technical	Ground Implementation	Airline Implementation	Source
1	Deploy FIS-B Nationally	Free access nationwide for basic weather and NAS status information to equipped aircraft						3								Y	Y	Y	Y	N	N	N	Y	Y	Y	N	Y	Y	N	Y	Y	N			4	2		1	1	1	2	OI - 103104
5	Autonomous Hazard Weather Alert Notification	Enhanced situations awareness via immediate simultaneous dissemination of hazardous weather to service providers, aircraft and airlines. **These products shall include microburst, turbulence and windshear warning in terminal airspace and shall be provided both automatically or upon pilot request.**			2	2		2		2						Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N				5		1	1	1	1	OI - 103117
10	Datalink to reduce routine workload	Expanded use of datalink for routine service provide activities to reduce workload.	2			2										Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N	N	N	Y	3		2	1		1	1	1	1	OI - 102114
15	Enhanced Emergency Alerting	Using GPS position and aircraft ID, locate distressed or downed aircraft through ADS-B							1							N	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	N	N	N				4		1	1	1	1	OI - 106202
20	Optimize Runway Assignments	Improve sequencing and spacing of arriving aircraft with tools for better management of runway assignment. Tool provide and deliver pilot instructions and wake vortex warnings. Also provides hooks for a path from runway to en-route to improve flow.					2		1	2						N	Y	Y	Y	N	N	N	Y	Y	N	N	Y	N	N	N	Y	Y	2	3	2			2	1	2	1	OI - 104114
25	Controller awareness of ACAS resolutions	The system shall support the delivery and display to controllers of any resolution advisories generated by aircraft ACAS systems.				1										N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N				4		1	1	1	1	RTO-24
29	Aircraft push of security video and aircraft performance during emergency	For the purposes of security, it may be valuable to have mechanisms to trigger the downlink of streaming video and audio of the cockpit and cabin environments and send down critical aircraft performance data.							2		2			2		Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	Y	N	N	Y				1	4	3	1	1	3	NA (similar to GCNSS Demo Segment A)
32	Push of Security advisories to aircraft	When an airspace emergency occurs, it would be desirable to quickly distribute notification to affected aircraft, AOC/FOC, ARTCC and other government agencies				2										Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N				1	3	2	1	1	1	NA (new)

Primary Operational Scenarios

Scenario Number	Scenario	Description	Communication Services												
			Party-line Voice	SA Voice	Broadcast Voice	Data Messaging	Tijaecotry exchange	Broadcast to Aircraft	Broadcast From Aircraft	Ground to Air Data	Air to Ground Data	Air to Air Data	Video Exchange	Vehicle Command and Control
1	Deploy FIS-B Nationally	Free access nationwide for basic weather and NAS status information to equipped aircraft						3						
5	Autonomous Hazard Weather Alert Notification	Enhanced situations awareness via immediate simultaneous dissemination of hazardous weather to service providers, aircraft and airlines. **These products shall include microburst, turbulence and windshear warning in terminal airspace and shall be provided both automatically or upon pilot request.**			2	2		2		2				
32	Push of Security advisories to aircraft	aircraft, ACCH GC, ARINC and other government agencies			2									

Primary Operational Scenarios



Scenario Number	Scenar	Airspace Domain							Aircraft Class						Information Classes				Benefits					Risk (1-Lowest)					Source
		Gate	Surface	Terminal	En-route	Remote	Oceanic	Polar	Transport	Cargo	Military	UAV	GA - Business	GA - Personal	Surveillance	Weather	AIM	Flight Objects	Airspace Capacity (5 is highest)	Airport Capacity (5 is highest)	Efficiency (5 is highest)	Safety (5 is highest)	Security (5 is highest)	Non-Technical	Technical	Ground Implementation	Airline Implementation	Source	Source
1	Deploy FIS-B Nationa																												- 103104
5	Autonomous Hazard V Notification																												- 103117
10	Datalink to reduce rou																												- 102114
15	Enhanced Emergency																												- 106202
20	Optimize Runway Ass																												- 104114
25	Controller awareness resolutions	Y	Y	Y	Y	N	N	N	Y	Y	Y	N	Y	Y	N	Y	Y	N			4	2		1	1	1	2	OI - 103104	O-24
29	Aircraft push of secur aircraft performance d emergency																												(similar GCNSS no gment A)
32	Push of Security advi	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N				5		1	1	1	1	OI - 103117	(new)

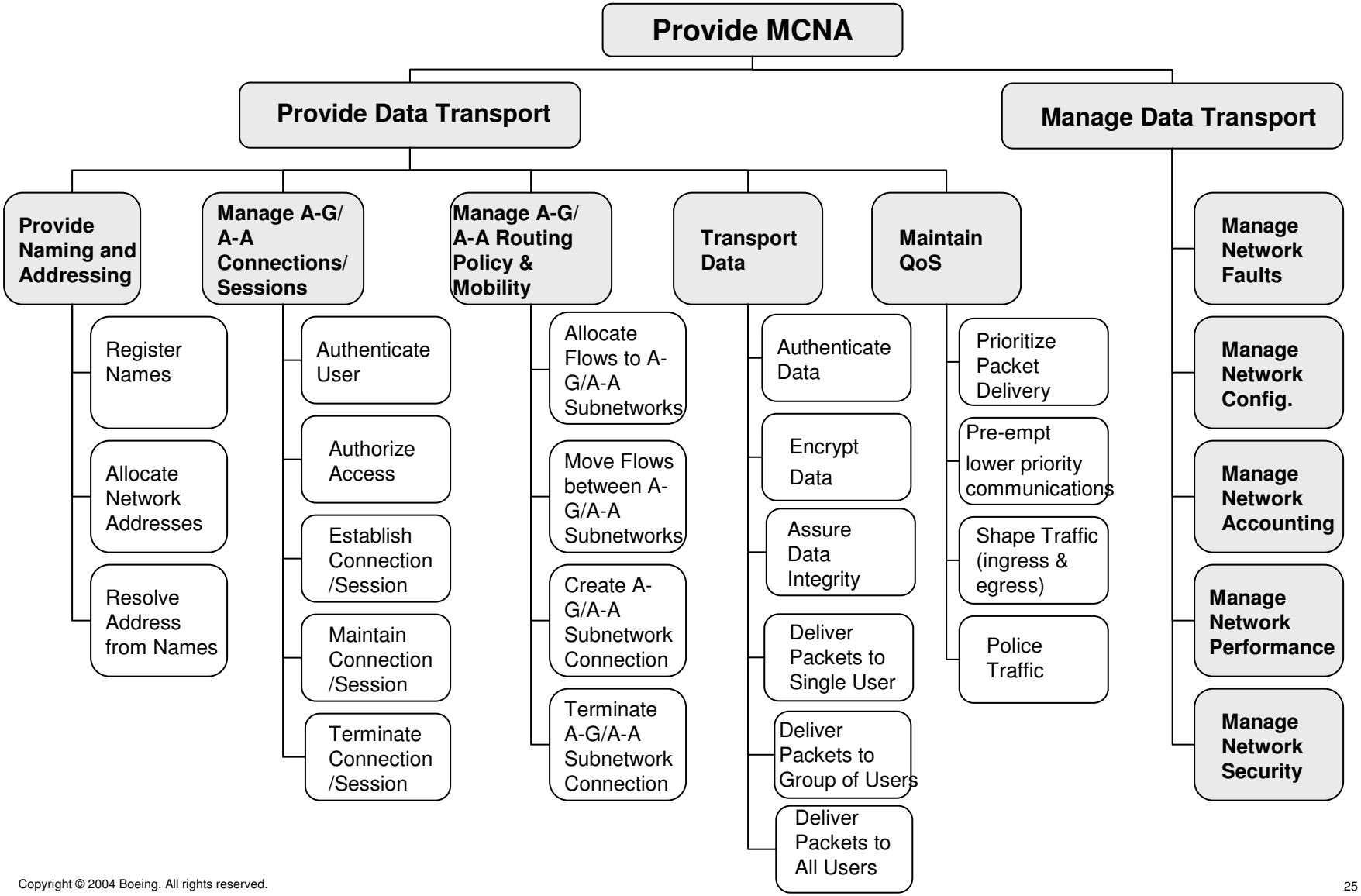
Secondary Scenarios

			Communication Services													Airspace Domain							Aircraft Class							Information Classes				Benefits					Risk (1-Lowest)				
Scenario Number	Scenario	Description	Party-line Voice	SA Voice	Broadcast Voice	Data Messaging	Trjaecotry exchange	Broadcast to Aircraft	Broadcast From Aircraft	Ground to Air Data	Air to Ground Data	Air to Air Data	Video Exchange	Vehicle Command and Control	Gate	Surface	Terminal	En-route	Remote	Oceanic	Polar	Transport	Cargo	Military	UAV	GA - Business	GA - Personal	Surveillance	Weather	AIM	Flight Objects	Airspace Capacity (5 is highest)	Airport Capacity (5 is highest)	Efficiency (5 is highest)	Safety (5 is highest)	Security (5 is highest)	Non-Technical	Technical	Ground Implementation	Airline Implementation	Source
16	Enhance Flight Data Management	FDP incorporates flight data info from flight deck into trajectory and conformance modeling. All plans treated as trajectories with protected volumes. Flight profiles can be negotiated and changes with strategic planners.					2								Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	3				3	1	2	2	2	OI - 101202
17	Interactive Flight Planning From Anywhere	Interactive feedback of proposed flight plans based upon all current constraints. Provide near real time flight plan negotiation and changes.					2								Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	1		3			2	2	2	1	OI - 101103
18	Oceanic Separation to RNP-4	Oceanic separation is reduce to 30nmi lateral and 30nmi longitudinal based upon GPS based navigation, ADS surveillance and satellite communications (ADS & CPDLC)	4			2	2								N	N	N	N	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	N	N	Y	3		3	1		1	1	1	1	OI - 107102
22	Flow Planning with distributed Schedule Recovery and Post Departure Rerouting	Distributed airline schedule recovery automation for utilizing combinations of ground delay, flight cancellation, and pre and post-departure re-routing to replan schedules in the face of convective weather disruptions. Take advantage of SWIM-enabled weather information distribution, improved forecasting, flight object, standardized route databases, and centralized allocation of forecast airport and airspace capacities					2								N	Y	Y	Y	N	N	N	Y	Y	N	N	Y	N	N	N	N	Y	2		4			2	2	2	1	SEA

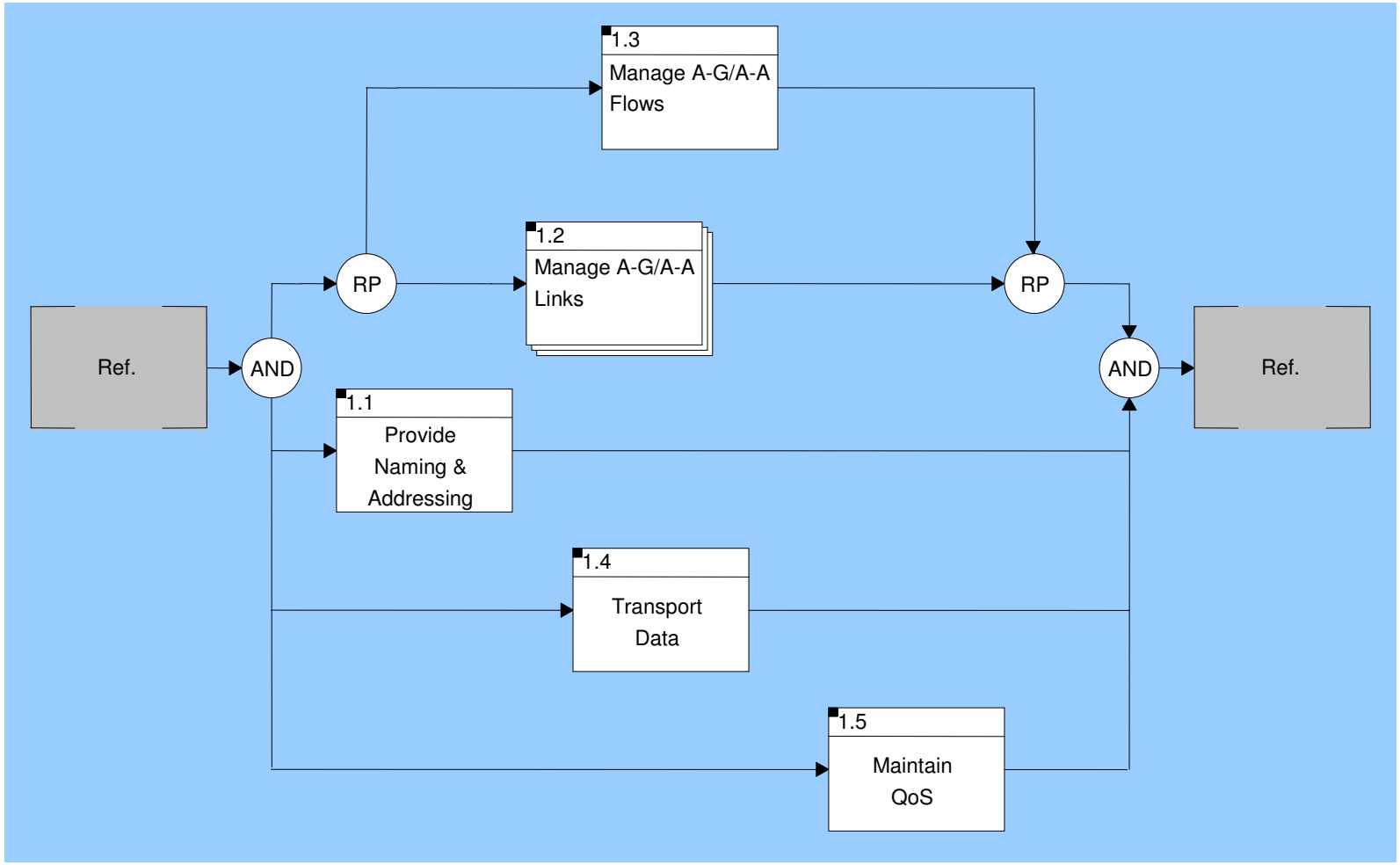
High Risk Scenarios

			Communication Services												Airspace Domain							Aircraft Class						Information Classes				Benefits					Risk (1-Lowest)				
Scenario Number	Scenario	Description	Party-line Voice	SA Voice	Broadcast Voice	Data Messaging	Trjaecotry exchange	Broadcast to Aircraft	Broadcast From Aircraft	Ground to Air Data	Air to Ground Data	Air to Air Data	Video Exchange	Vehicle Command and Control	Gate	Surface	Terminal	En-route	Remote	Oceanic	Polar	Transport	Cargo	Military	UAV	GA - Business	GA - Personal	Surveillance	Weather	AIM	Flight Objects	Airspace Capacity (5 is highest)	Airport Capacity (5 is highest)	Efficiency (5 is highest)	Safety (5 is highest)	Security (5 is highest)	Non-Technical	Technical	Ground Implementation	Airline Implementation	Source
9	Shared Responsibility for Horizontal Separation	Delegate separation responsibility to pilots when it is operationally beneficial to do so.	3						1			1			N	N	N	Y	Y	N	N	Y	Y	Y	Y	Y	N	Y	N	N	N	3		1			3	3	1	3	OI - 102118
13	Improved Surface Separation Assurance	Pilots are provided high definition surface target information such as position, identification, velocity and infrastructure location (runways, taxiways etc.). On board automation systems display and advise the flight crew on surface movements and potential conflicts.	2			1			1	2					Y	Y	N	N	N	N	N	Y	Y	N	Y	Y	N	Y	N	Y	Y		2		4		2	2	1	3	OI - 102408
30	ROA Control	Ground control of an unpiloted aircraft	2			2				1	1			1	N	Y	Y	Y	Y	Y	Y	N	N	N	Y	N	N	Y	Y	N	N						4	4	4	4	NA (new)
31	UAV Control	Autonomous control of an unpiloted aircraft with ground management					1	2	1	2	2				N	Y	Y	Y	Y	Y	Y	N	N	N	Y	N	N	Y	Y	Y	Y						4	4	4	4	NA (new)
36	Dynamic Resectorization	Provides tools to allow for more defintion of aispace configuration changes with automated functions to evaluate and develop asset assignments. Supports system to system coordination (SYSCO) of the reassignments across facility boundaries.	2			1	2	1	1						N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y										OI - 108207

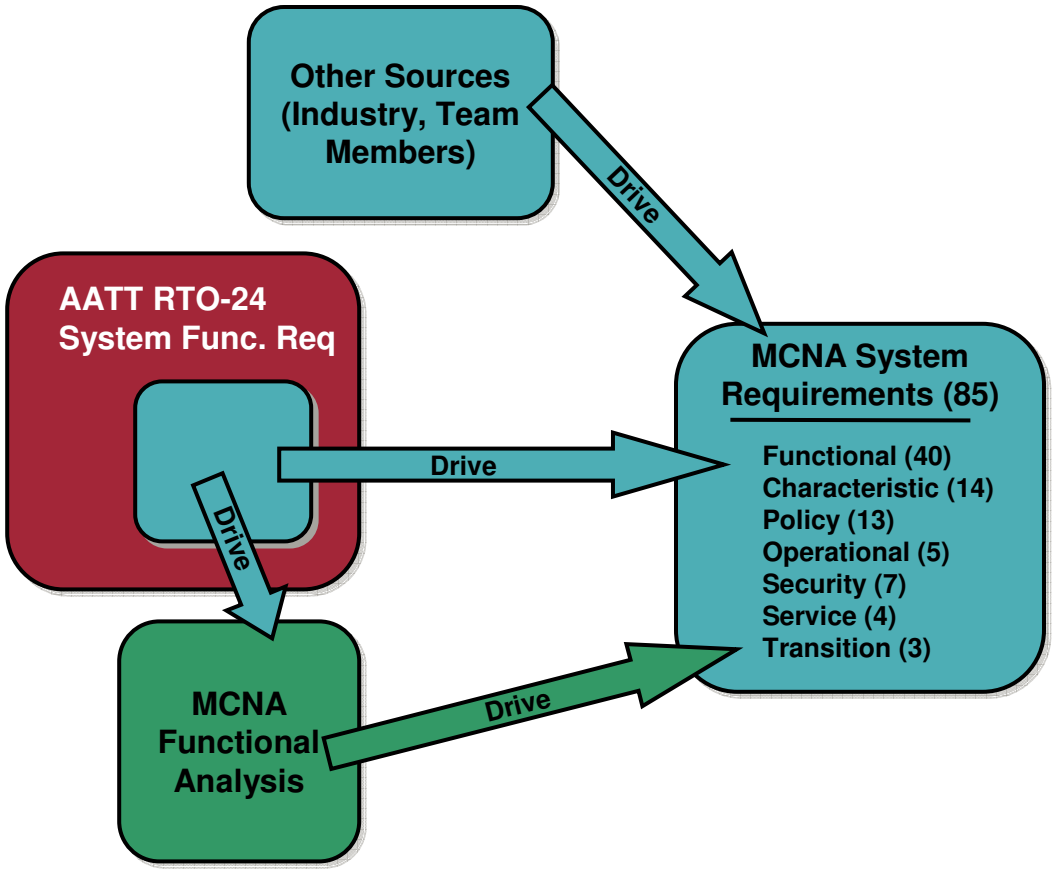
MCNA Functional Architecture



Example FFBD: Provide Data Transport



MCNA System Requirements



MCNA System Requirements Summary

Requirement Type	Description	Number
Functional	Requirements related to the functions provided by MCNA.	40
Characteristic	Requirements related to the characteristics of MCNA.	14
Policy	Requirements that are related to FAA/ATM policy.	13
Operational	Requirements that govern the use of the MCNA.	5
Security	Requirements related to the protection of data being communicated from malicious attack, being divulged to unknown/unauthorized parties.	7
Service	Requirements that capture the nature of the services that MCNA is required to provide.	4
Transition	Requirements imposed to assure seamlessly inter-operation during transition from exiting infrastructure to new infrastructure.	3

Communication Services Philosophy

- **The Concept of Communication Service Classes and Levels is the key abstraction that allows decoupling between candidate communication links and operational scenarios**
- **Based upon the concept of RCP**
  - **Most closely related to the MACONDO effort**
  - **RNP (and the PARC RCP effort) define a set of services that are specific to separation management**
  - **These RNP/RCP levels would associate to the levels of a single Communication Service Class**
  - **MCNA supports a much wider range of applications than separation management**
    - **Must define a representative selection of Communication Service Classes**

Voice Communication Service Classes and Performance Requirements

Service Class	Service Level	Designator	Description
Party Line Voice	1	RCP-PLV1	Emergency Party Line Service
	2	RCP-PLV2	Terminal area and surface party line voice
	3	RCP-PLV3	En-route Party line voice
	4	RCP-PLV4	Oceanic, Remote or AOC Party line voice
Selective Addressed Voice	1	RCP-VSA1	En-route ATC telephony
	2	RCP-VSA2	Oceanic, Remote, AOC or DHS telephony
	3	RCP-VSA3	Passenger telephony
Broadcast Voice	1	RCP-VB1	Emergency voice broadcast
	2	RCP-VB2	Info broadcast via voice (e.g. ATIS)

Service Class	Service Level	Mean Latency	Call Establishment Time	Availability	Continuity	Integrity (BER)	Security
Party Line Voice	1	350ms	150ms	0.993	0.998	1.00E-03	NA
	2	350ms	150ms	0.993	0.998	1.00E-03	Authentication
	3	350ms	150ms	0.993	0.998	1.00E-03	Authentication
	4	350ms	20s	0.993	0.995	1.00E-03	Authentication
Selective Addressed Voice	1	350ms	5s	0.993	0.998	1.00E-03	Authentication
	2	485ms	20s	0.993	0.995	1.00E-03	Authentication
	3	485ms	40s	0.993	0.95	1.00E-03	Authentication
Broadcast Voice	1	485ms	NA	0.99999	0.998	1.00E-03	NA
	2	485ms	NA	0.99	0.995	1.00E-03	NA

Data Communication Service Classes

Service Class	Service Level	Designator	Description
Data Messaging	1	RCP-DM1	Tactical CPDLC: D-ALERT, URCO, ACL, D-TAXI
	2	RCP-DM2	Strategic CPDLC: DLL, ACM, FLUP, D-RVR, PPD, ACL, DCL, D-TAXI, AMC, AUTO-CPDLC
	3	RCP-DM3	Routine CDPLC: DLL, ACM, D-ATIS, D-SIGMET, D-ORIS, DSC
	4	RCP-DM4	AOC "ACARS": OOOI, NOTAM, METAR, TAF, weather request, position report, flight status, fuel status, flight plan request, load sheet request
Trajectory Exchange	1	RCP-TE1	Tactical Trajectory Update: COTRAC, FLIPSY, FLIPINT
	2	RCP-TE2	Strategic Trajectory Update: FLIPINT, ARMAND, GRECO, DYNAV, ACL, DCL, D-TAXI
Broadcast to Aircraft	1	RCP-BTA1	TIS-B for self separation
	2	RCP-BTA2	TIS-B for situational awareness
	3	RCP-BTA3	FIS-B
Broadcast from Aircraft	1	RCP-BFA1	ADS-B for self separation (terminal & surface)
	2	RCP-BFA2	ADS-B for self separation (en-route)
	3	RCP-BFA3	ADS-B for situational awareness
Ground to Air Data	1	RCP-FU1	Tactical SWIM services
	2	RCP-FU2	Strategic SWIM services
	3	RCP-FU3	Informational SWIM services
Air to Ground Data	1	RCP-FD1	Tactical SWIM services
	2	RCP-FD2	Strategic SWIM services
	3	RCP-FD3	Informational SWIM services
Air to Air Data	1	RCP-AAD1	Collision avoidance resolution
	2	RCP-AAD2	Free flight conflict resolution
	3	RCP-AAD3	Self-separation resolution
Video Exchange	1	RCP-V1	ROA aircraft view downlink
	2	RCP-V2	DHS situation downlink
Command & Control	1	RCP-CC1	ROA CC Level 1 - Commercial airspace (maybe) and over populated areas
	2	RCP-CC2	ROA CC Level 2 - SUA over populated areas
	3	RCP-CC3	ROA CC Level 3 - Operation in SUA over unpopulated areas

Data Communication Performance Requirements

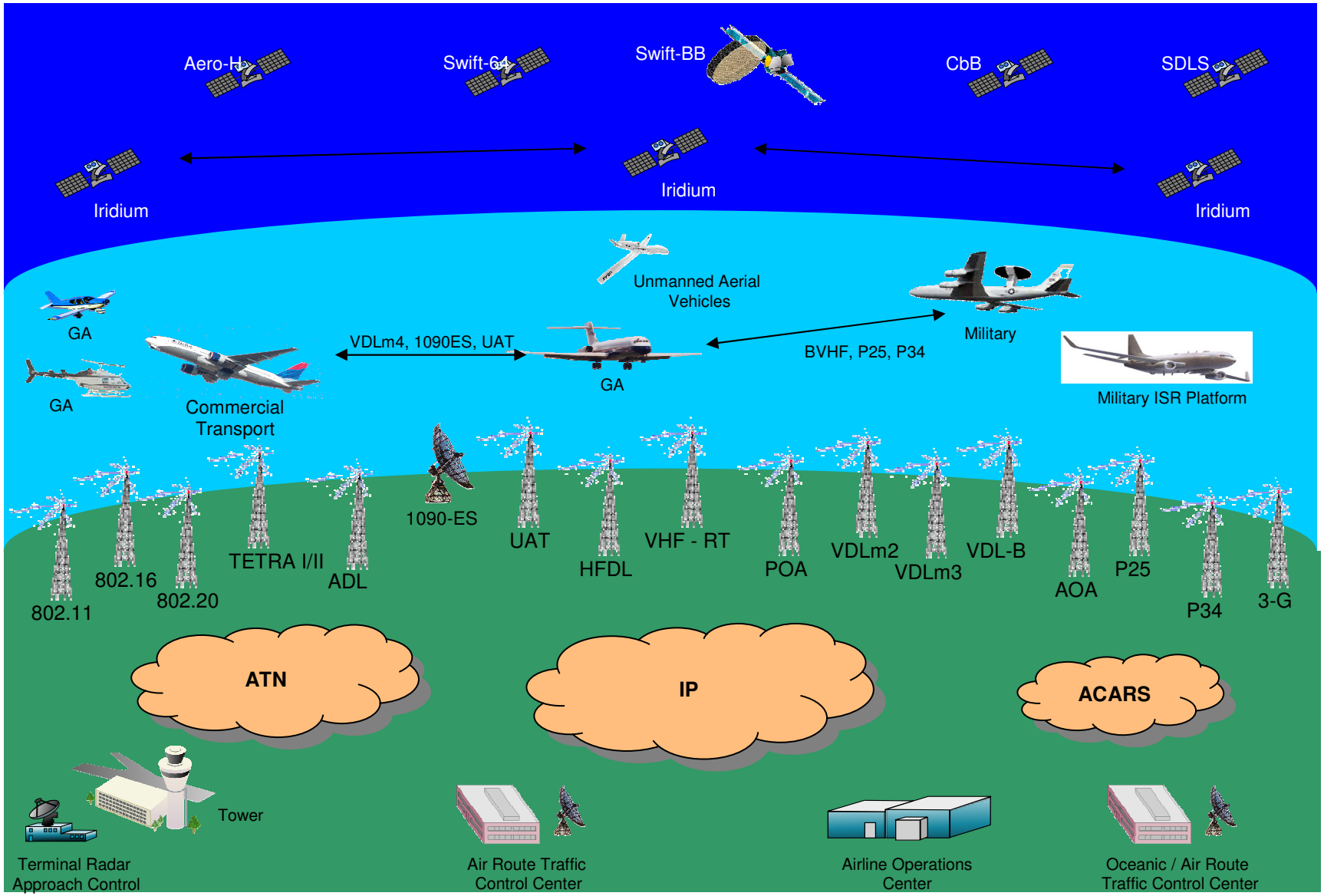
Service Class	Service Level	95% Message Latency* (secs)	Expiration Time (secs)	Availability	Continuity	Integrity (Undetected PLR)	Security
Data Messaging	1	2	20	0.9995	0.995	1.00E-05	Authentication, Confidentiality
	2	5	40	0.9995	0.995	1.00E-05	Authentication
	3	10	60	0.9995	0.995	1.00E-05	Authentication
	4	30	120	0.9995	0.995	1.00E-05	Authentication
Trajectory Exchange	1	30	120	0.9995	0.995	1.00E-08	Authentication, Confidentiality
	2	30	120	0.9995	0.995	1.00E-08	Authentication, Confidentiality
Broadcast to Aircraft	1	3	5	0.9995	0.995	1.00E-05	Authentication
	2	5	15	0.999	0.99	1.00E-05	Authentication
	3	30	60	0.999	0.99	1.00E-05	Authentication
Broadcast from Aircraft	1	3	5	0.999	0.99	1.00E-05	N/A
	2	5	15	0.999	0.99	1.00E-05	N/A
	3	10	20	0.999	0.99	1.00E-05	N/A
Ground to Air Data	1	5	40	0.999	0.99	1.00E-05	Authentication
	2	10	60	0.999	0.99	1.00E-05	Authentication
	3	30	120	0.999	0.99	1.00E-05	Authentication
Air to Ground Data	1	5	40	0.999	0.99	1.00E-05	Authentication
	2	10	60	0.999	0.99	1.00E-05	Authentication
	3	30	120	0.999	0.99	1.00E-05	Authentication
Air to Air Data	1	3	20	0.999	0.99	1.00E-05	N/A
	2	5	40	0.9995	0.995	1.00E-05	N/A
	3	30	120	0.9995	0.995	1.00E-05	N/A
Video Exchange	1	1	2	0.99999	0.999	1.00E-05	Authentication, Confidentiality
	2	5	40	0.999	0.99	1.00E-05	Authentication, Confidentiality
Command & Control	1	1	2	0.999999	1	1.00E-08	Authentication, Confidentiality
	2	1	2	0.99999	0.999	1.00E-08	Authentication, Confidentiality
	3	1	2	0.9999	0.99	1.00E-08	Authentication, Confidentiality

*** Based on 1kbit packet**

MCNA Architecture

Karl Griep & Mark Taylor
MCNA Final Briefing
15 August 2005

MCNA Context



Candidate Links Evaluation Table

Boeing Technology | Phantom Works

GCNSS Phase II

General Characteristics						Communication Services										Airspace Domain							Aircraft Class						Risk (1-3)				Cost (0- 6)				Link Type		
Candidate Link Type	Link ID Number	Associated Networking Protocols	Spectrum	SWIM Support (3 is highest)	Availability (date)	Party-line Voice	SA Voice	Broadcast Voice	Data Messaging	Trajectory exchange	Broadcast to Aircraft	Broadcast From Aircraft	Ground to Air Data	Air to Ground Data	Air to Air Data	Video Exchange	Vehicle Command and Control	Gate	Surface	Terminal	En-route	Remote	Oceanic	Polar	Transport	Cargo	Military	UAV/ROA	GA - Business	GA - Personal	TRL	Standardization	Certifiability	Political	System	Maintenance	Service	Avionics	A-G	A-A	A-S
Air-Ground Communications																																								
VHF Analog Voice	1	NA	VHF	0	2005	1		1										Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	1	1	1	1	0	4	0	1	Y	Y	N
HF Analog Voice	2	NA	HF	0	2005		3											N	N	N	N	Y	Y	Y	Y	Y	Y	N	N	N	1	1	1	1	0	2	0	3.5	Y	Y	N
Plain old ACARS (POA)	3	ACARS	VHF	1	2005				3									Y	Y	Y	Y	N	N	N	Y	Y	N	N	Y	N	1	1	1	1	0	0	3	2	Y	N	N
VDLm2	4	ACARS	VHF	1	2005				3				3	3				Y	Y	Y	Y	N	N	N	Y	Y	N	N	Y	N	1	1	1	1	0	0	2.5	2.5	Y	N	N
	5	CLNP	VHF	2	2010			2	2	2			3	3											Y	Y	N	N	Y	N	1	1	1	2	0	0	2.5	2.5			
	6	IP	VHF	2	2010			2	3		3	3	3	3											Y	Y	N	N	Y	N	2	3	3	2	0	0	2.5	2.5			
	7	NA (VDL-B)	VHF	2	2005						2														Y	Y	Y	Y	Y	Y	1	1	1	1	2	2	0	2			
VDLm3	8	CLNP	VHF, DME	2	2020				1	1							2	Y	Y	Y	Y	N	N	N	Y	Y	N	Y	Y	N	1	1	1	3	4	3	0	2.5	Y	N	N
	9	Voice		1	2015	1		1																														Y	Y	N
HFDL	10	ACARS	HF	1	2005				3									N	N	N	N	Y	Y	Y	Y	Y	Y	N	N	N	1	1	1	1	0	0	3.5	3.5	Y	N	N
	11	CLNP			2010																																			
3G	12	IP	DME	3	2020	3	2	1	1	1	1	1	1	1		2	2	Y	Y	Y	Y	N	N	N	Y	Y	N	N	Y	Y	2	3	3	2	3	3	0	3	Y	N	N
Satellite Communications																																								
Aero-H	13	ACARS (data-2)	AMSRS	1	2005																										1	1	1	1							
	14	CLNP (data-3)			2010		2		2	2								Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	2	2	2	1	0	0	5	4.5	N	N	Y
	15	IP (data-3)			2010																										2	2	2	2							
Swift-64	16	IP	AMSRS	1	2005		3	1	3		3	3	3	3			3	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	1	3	3	2	0	0	3	4	N	N	Y
Swift-Broadband	17	IP	AMSRS	3	2010	3	2	1	1	1	2	3	1	1		2	2	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	2	2	2	2	0	0	2	4	N	N	Y
SDARS	18	IP	S-Band	2	2015			1			2							Y	Y	Y	Y	N	N		Y	Y	N	N	Y	Y	2	3	3	2	0	2	0	1.5	N	N	Y
SDLS	19	NA	AMSRS	2	2015	3	1	1	1	1	2	3	1	1				Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	3	3	3	3	2	3	0	3	N	N	Y
Iridium	20	Layer-2	L-Band	1	2005		3		3		3							Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1	2	3	3	0	0	2.5	2	N	N	Y
Connexion by Boeing	21	IP	FSS	3	2005	4	3	2	3		3	3	3	3		2	3	N	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	1	3	3	3	0	0	2	6	N	N	Y
Air-Air Communications																																								
1090-ES	22	CLNP	DME	1	2010				2	2					1			N	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	N	1	1	1	1	1	1	0	2	Y	Y	N
	23	Layer-2	DME	1	2005						1	1						Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N										
UAT	24	Layer-2	DME	2	2010						1	1						N	Y	Y	Y	Y	N	N	N	N	N	N	Y	Y	1	1	2	2	3	3	0	3	Y	Y	N
VDLm4	25	CLNP	VHF	1	2010							1			1			N	N	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	1	1	2	3	0	0	0	3	N	Y	N
B-VHF	26	CLNP	VHF, DME	3	2025	1	1	1	1	1			1	1	1		2	Y	Y	Y	Y	N	N	N	Y	Y	N	Y	Y	N	3	3	3	2	4.5	3	0	3	Y	Y	N
	27	IP				1	1	1	1	1	1		1	1	1		2																							
P-25	28	IP	DME	1	2020	1	1	1	3									Y	Y	Y	N	N	N	N	Y	Y	Y	N	Y	Y	2	3	3	2	4	3	0	3	Y	Y	N
P-34	29	IP	DME, MLS	3	2025	2	2	1	1	1	1	1	1	1	2	2	2	Y	Y	Y	Y	N	N	N	Y	Y	N	Y	Y	N	2	3	3	2	5	4	0	3	Y	Y	N
Airport Communications																																								
Airport Data Link (ADL)	30	NA	MLS	3	2025	2	1	1	1	1	1	3	1	1		1	1	Y	Y	N	N	N	N	N	Y	Y	N	N	Y	Y	3	3	3	2	2	2	0	3	Y	N	N
IEEE 802.11	31	IP	ISM	3	2010			2	3		3		3	3				Y	N	N	N	N	N	N	Y	Y	N	N	Y	Y	1	2	3	2	1.5	1.5	0	2	Y	N	N
	32	CLNP			2015			2	3				3	3																										
IEEE 802.16	33	IP	ISM, MLS	3	2020	2	1	1	1	1	1	1	1	1	1	1	1	Y	Y	N	N	N	N	N	Y	Y	N	N	Y	Y	1	3	3	2	2	2	0	3	Y	N	N
	34	CLNP				2	1	1	1	1			1	1	1	1	1																							
IEEE 802.20	35	IP	ISM, DME	3	2025	2	2	1	1	1	2	2	1	1		2	2	Y	Y	N	N	N	N	N	Y	Y	N	N	Y	Y	2	3	3	2	2	2	0	3	Y	N	N
	36	CLNP				2	1	1	1	1		2	1	1		2	2																							
TETRA I/II	37	IP	DME	2	2025	1	1	1	1	1	1	1					1	Y	Y	N	N	N	N	N	Y	Y	N	N	Y	Y	2	3	3	2	2	2	0	3	Y	N	N

Candidate Links Evaluation Table

General Characteristics						Communication Services											Airspace Domain	Aircraft Class	Risk (1-3)	Cost (0- 6)	Link Type		
Candidate Link Type	Link ID Number	Associated Networking Protocols	Spectrum	SWIM Support (3 is highest)	Availability (date)	Party-line Voice	SA Voice	Broadcast Voice	Data Messaging	Trajectory exchange	Broadcast to Aircraft	Broadcast From Aircraft	Ground to Air Data	Air to Ground Data	Air to Air Data	Video Exchange	Vehicle Command and Control	Gate	Avionics	A-G	A-A	A-S
Air-Ground Communicatio																						
VHF Analog Voice	1	NA	VHF	0	2005	1		1										Y	1	Y	Y	N
HF Analog Voice	2	NA	HF	0	2005		3											N	3.5	Y	Y	N
Plain old ACARS (POA)	3	ACARS	VHF	1	2005				3									Y	2	Y	N	N
VDLm2	4	ACARS	VHF	1	2005				3				3	3				Y	2.5	Y	N	N
	5	CLNP	VHF	2	2010			2	2	2			3	3					2.5			
	6	IP	VHF	2	2010			2	3		3	3	3	3					2.5			
	7	NA (VDL-B)	VHF	2	2005						2								2			
VDLm3	8	CLNP	VHF, DME	2	2020				1	1							2	Y	2.5	Y	N	N
	9	Voice		1	2015	1		1												Y	Y	N
HFDL	10	ACARS	HF	1	2005				3									N	3.5	Y	N	N
	11	CLNP			2010														3	Y	N	N
3G	12	IP	DME	3	2020	3	2	1	1	1	1	1	1	1		2	2	Y	3	Y	Y	N
Satellite Communicatio																						
Aero-H	13	ACARS (data-2)	AMSRS	1	2005														3	Y	Y	N
	14	CLNP (data-3)			2010		2		2	2								Y	3	Y	N	N
	15	IP (data-3)			2010														2	Y	N	N
Swift-64	16	IP	AMSRS	1	2005		3	1	3		3	3	3	3			3	Y	3	Y	N	N
Swift-Broadband	17	IP	AMSRS	3	2010	3	2	1	1	1	2	3	1	1		2	2	Y	3	Y	N	N

Candidate Links Evaluation Table

General Characteristics			Communication Services							Airspace Domain						Aircraft Class				Risk (1-3)				Cost (0- 6)				Link Type		
Candidate Link Type	Link ID Number		Video Exchange	Vehicle Command and Control	Gate	Surface	Terminal	En-route	Remote	Oceanic	Polar	Transport	Cargo	Military	UAV/ROA	GA - Business	GA - Personal	TRL	Standardization	Certifiability	Political	System	Maintenance	Service	Avionics	A-G	A-A	A-S
VHF Analog Voice	1																													
HF Analog Voice	2																													
Plain old ACARS (POA)	3	A																												
VDLm2	4	A																												
	5	C																												
	6																													
	7	NA																												
VDLm3	8																													
	9																													
HFDL	10	A																												
	11																													
3G	12																													
Aero-H	13	ACAR																												
	14	CLN																												
	15	IP																												
Swift-64	16																													
Swift-Broadband	17																													
SDARS	18																													
SDLS	19																													
Iridium	20	L																												
Connexion by Boeing	21																													
1090-ES	22																													
	23	L																												
UAT	24	L																												
VDLm4	25																													
B-VHF	26																													
	27																													
P-25	28																													
P-34	29																													
Airport Data Link (ADL)	30																													
IEEE 802.11	31																													
	32																													
IEEE 802.16	33																													
	34																													
IEEE 802.20	35																													
	36																													
TETRA I/II	37																													

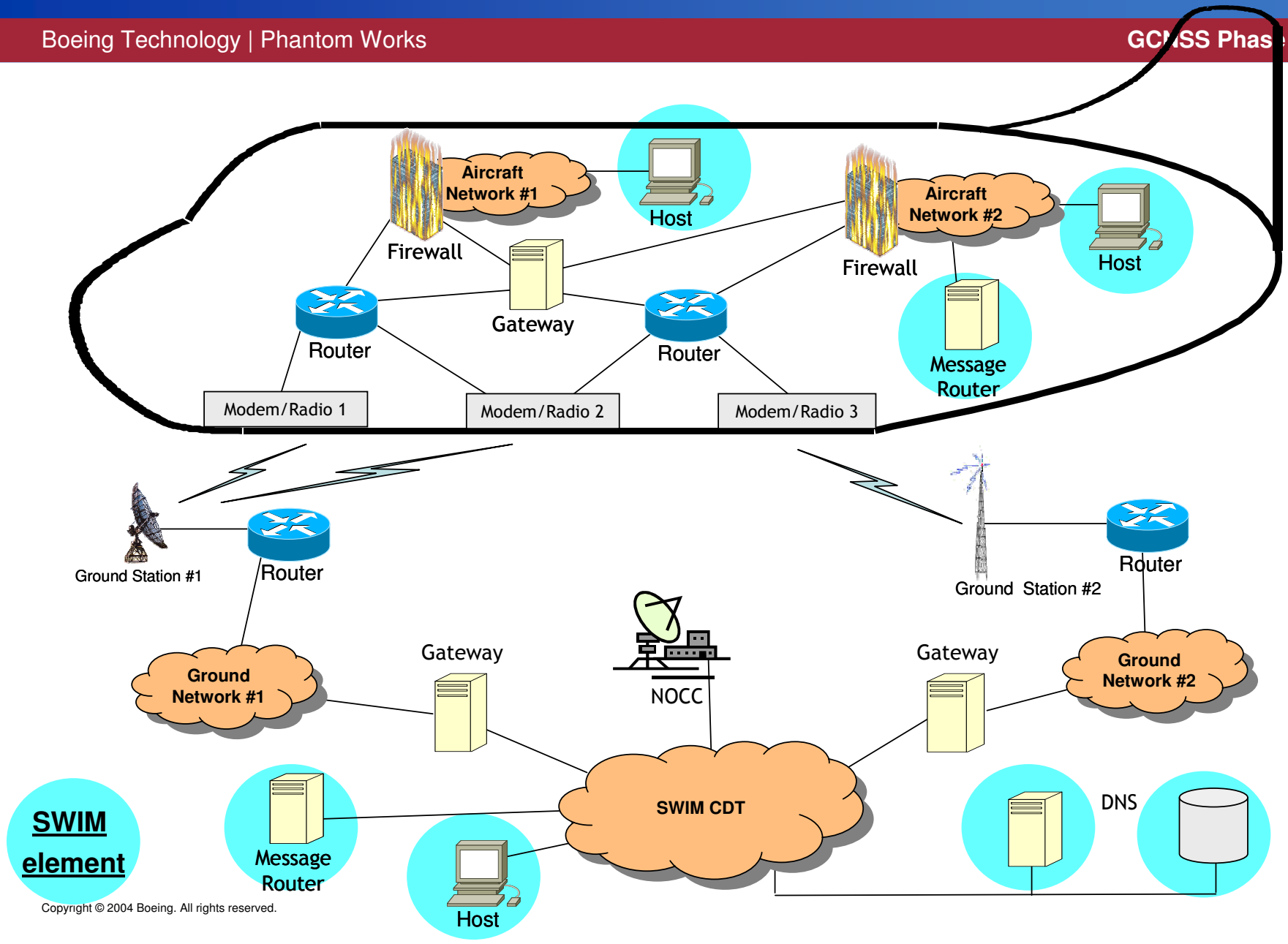
		Airspace Domain							Aircraft Class						Risk (1-3)				Cost (0- 6)				Link Type		
		Gate	Surface	Terminal	En-route	Remote	Oceanic	Polar	Transport	Cargo	Military	UAV/ROA	GA - Business	GA - Personal	TRL	Standardization	Certifiability	Political	System	Maintenance	Service	Avionics	A-G	A-A	A-S
nmunications																									
		Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	1	1	1	1	0	4	0	1	Y	Y	N
		N	N	N	N	Y	Y	Y	Y	Y	Y	N	N	N	1	1	1	1	0	2	0	3.5	Y	Y	N
		Y	Y	Y	Y	N	N	N	Y	Y	N	N	Y	N	1	1	1	1	0	0	3	2	Y	N	N
		Y	Y	Y	Y	N	N	N	Y	Y	N	N	Y	N	1	1	1	1	0	0	2.5	2.5	Y	N	N
									Y	Y	N	N	Y	N	1	1	1	2	0	0	2.5	2.5			
									Y	Y	N	N	Y	N	2	3	3	2	0	0	2.5	2.5			
									Y	Y	Y	Y	Y	Y	1	1	1	1	2	2	0	2			
	2	Y	Y	Y	Y	N	N	N	Y	Y	N	Y	Y	N	1	1	1	3	4	3	0	2.5	Y	N	N
																							Y	Y	N
		N	N	N	N	Y	Y	Y	Y	Y	Y	N	N	N	1	1	1	1	0	0	3.5	3.5	Y	N	N
2	2	Y	Y	Y	Y	N	N	N	Y	Y	N	N	Y	Y	2	3	3	2	3	3	0	3	Y	N	N
munications																									
		Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	1	1	1	1	0	0	5	4.5	N	N	Y
															2	2	2	1							
															2	2	2	2							
	3	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	1	3	3	2	0	0	3	4	N	N	Y
2	2	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	2	2	2	2	0	0	2	4	N	N	Y

Candidate Links Evaluation Table

General Characteristics					Communication Services			Airspace Domain		Aircraft Class				Risk (1-3)		Cost (0- 6)				Link Type	
				est)			ontrol														
SDARS	18		IP		S-Band	2		2015				1			2						
SDLS	19		NA		AMSRS	2		2015	3	1	1	1	1	2	3	1	1				
Iridium	20		Layer-2		L-Band	1		2005		3		3		3							
Connexion by Boeing	21		IP		FSS	3		2005	4	3	2	3		3	3	3	3		2	3	
Air-Air Communicati																					
1090-ES	22		CLNP		DME	1		2010				2	2					1			
	23		Layer-2		DME	1		2005						1	1						
UAT	24		Layer-2		DME	2		2010						1	1						
VDLm4	25		CLNP		VHF	1		2010							1			1			
B-VHF	26		CLNP		VHF, DME	3		2025	1	1	1	1	1			1	1	1		2	
	27		IP						1	1	1	1	1	1		1	1	1		2	
P-25	28		IP		DME	1		2020	1	1	1	3									
P-34	29		IP		DME, MLS	3		2025	2	2	1	1	1	1	1	1	1	2	2	2	
Airport Communicati																					
Airport Data Link (ADL)	30		NA		MLS	3		2025	2	1	1	1	1	1	3	1	1		1	1	
IEEE 802.11	31		IP		ISM	3		2010			2	3		3		3	3				
	32		CLNP					2015			2	3				3	3				
IEEE 802.16	33		IP		ISM, MLS	3		2020	2	1	1	1	1	1	1	1	1	1	1	1	
	34		CLNP						2	1	1	1	1			1	1	1	1	1	
IEEE 802.20	35		IP		ISM, DME	3		2025	2	2	1	1	1	2	2	1	1		2	2	
	36		CLNP						2	1	1	1	1		2	1	1		2	2	
TETRA I/II	37		IP		DME	2		2025	1	1	1	1	1	1	1					1	

Airport Communications																																								
Airport Data Link (ADL)	30	NA	MLS	3	2025	2	1	1	1	1	1	3	1	1		1	1	Y	Y	N	N	N	N	N	Y	Y	N	N	Y	Y	3	3	3	2	2	2	0	3	Y	N	N
IEEE 802.11	31	IP	ISM	3	2010			2	3		3		3	3				Y	N	N	N	N	N	N	Y	Y	N	N	Y	Y	1	2	3	2	1.5	1.5	0	2	Y	N	N
	32	CLNP			2015			2	3				3	3																											
IEEE 802.16	33	IP	ISM, MLS	3	2020	2	1	1	1	1	1	1	1	1	1	1	1	Y	Y	N	N	N	N	N	Y	Y	N	N	Y	Y	1	3	3	2	2	2	0	3	Y	N	N
	34	CLNP				2	1	1	1	1			1	1	1	1	1																								
IEEE 802.20	35	IP	ISM, DME	3	2025	2	2	1	1	1	2	2	1	1		2	2	Y	Y	N	N	N	N	N	Y	Y	N	N	Y	Y	2	3	3	2	2	2	0	3	Y	N	N
	36	CLNP				2	1	1	1	1		2	1	1		2	2																								
TETRA I/II	37	IP	DME	2	2025	1	1	1	1	1	1	1					1	Y	Y	N	N	N	N	N	Y	Y	N	N	Y	Y	2	3	3	2	2	2	0	3	Y	N	N

MCNA Physical Architecture



Individual Network Technology Implementations

	ACARS	ATN	IP (near term)	IP (far term)
Mobility	Messaging (air initiated)	IDRP updates, limited # of routers, Air initiated CM	Layer 7 routing and addressing (via IP messaging). Mobile users must log into message servers. During handover, new logon effects handover	MIPv6, NeMo
Multi-homing	Provided through MU/CMU configuration and by DSP (does ACARS provide multi-homing across DSP)	IDRP	SCTP or IP-based messaging with redundant channels opened over each available link with unique handles to provide message router with link selection control	Multi6 is the group most likely to provide a solution to this problem, but their effort are still preliminary
Policy based routing	ACARS MU can be configured to send messages first over VHF, next HF finally SatCom	IDRP	Message routers would require custom logic to route particular message via particular routers to achieve policy based routing.	Multi6 is the group most likely to provide a solution to this problem, but their effort are still preliminary
QoS	Generally NA, SITA differentiates AOC and ATC traffic onto different G-G networks	Strict priority queuing (16 levels)	DiffServ	DiffServ
Security (Application & Network)	NA, Honeywell Secure ACARS (based upon ATN Security Services)	ATN Security Services (application layer security)	Limited SWIM Security Services (based upon ATN Security Services)	SWIM Security Services (may also include network or transport layer security, but defense in depth has cost in latency and overhead)
Security (On-board Aircraft)	NA, Restricted Physical Access	NA, Restricted Physical Access	TBD - AFDX (provides limited access and requires config change to add new safety systems), VLANs ???, Firewalls, etc.	TBD - AFDX (provides limited access and requires config change to add new safety systems), VLANs ???, Firewalls, etc.
Multicast	NA	NA	IP Multicast with special interworking at layer-2 to efficient map from IP-Multicast addresses to Layer-2 multicast or broadcast addresses.	IP Multicast with special interworking at layer-2 to efficient map from IP-Multicast addresses to Layer-2 multicast or broadcast addresses.

Inter-Protocol Accommodation

Protocol making Accommodation

Protocol being Accommodated

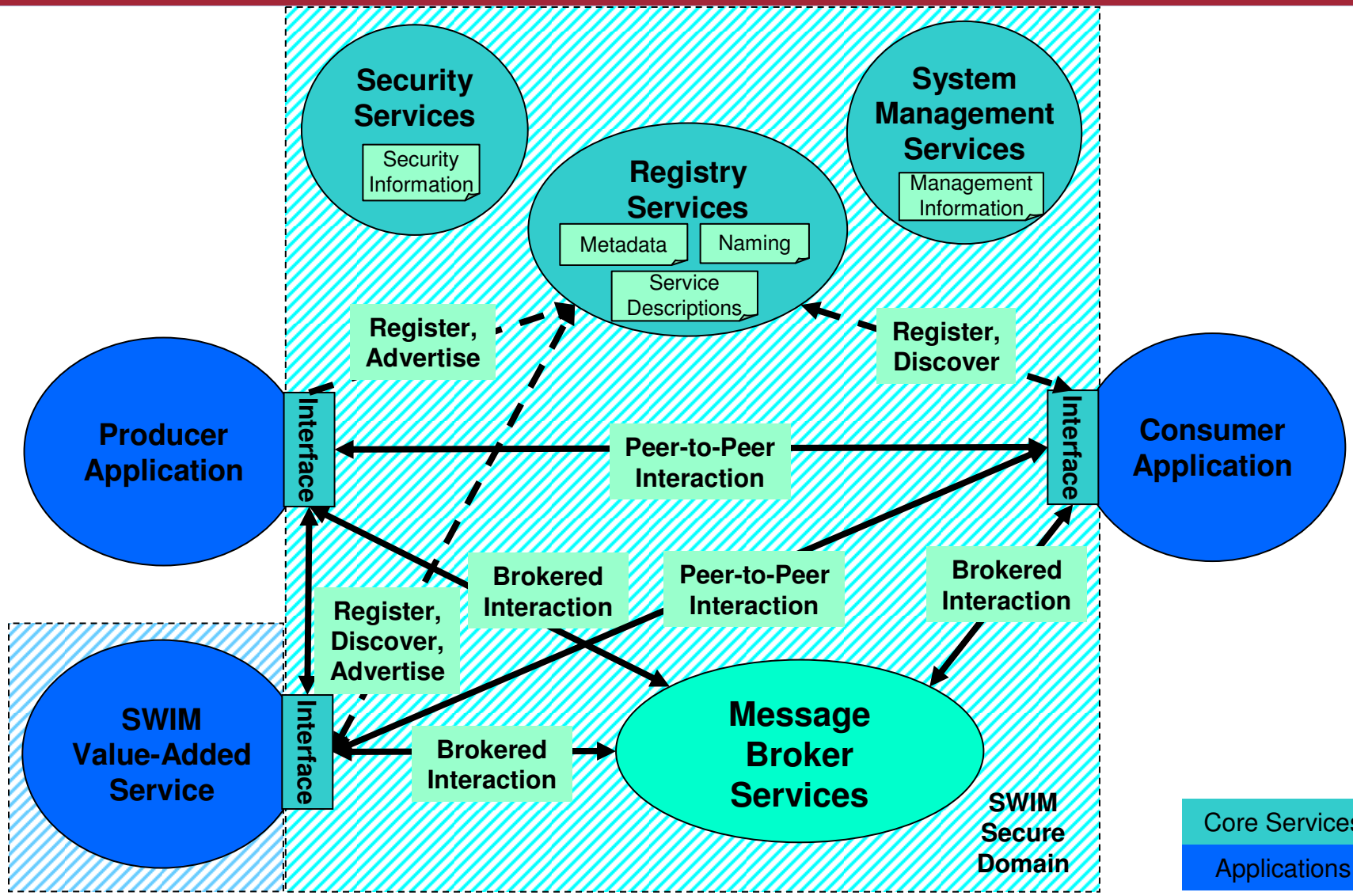
	ACARS	ATN (CLNP)	IP
ACARS	**NA**	**Messaging: Yes, probably via IP message gateway and transport via ATN Network Tunnel: Yes, Probably GACS**	**Messaging: Yes, for messaging services via message tunnel Network Tunnel: Yes**
ATN (CLNP)	**Messaging: No Network Tunnel: No POA is not a good candidate for future convergence, HFDL requires RTP implementations**	**NA**	**Messaging: Not easily due to the need to split the TP-4 connections inherent in the ATN specification Network Tunnel: Yes, with SNDCF to move mobility and multi-homing reponsibility entirely to ATN**
IP	**Messaging: Yes, for messaging services via message tunnel Network Tunnel: No**	**Messaging: Yes, for messaging services via message bridge Network Tunnel: Yes**	**NA**

The NAS capability for authorized parties to access the right information in the right format at the right time regardless of location.

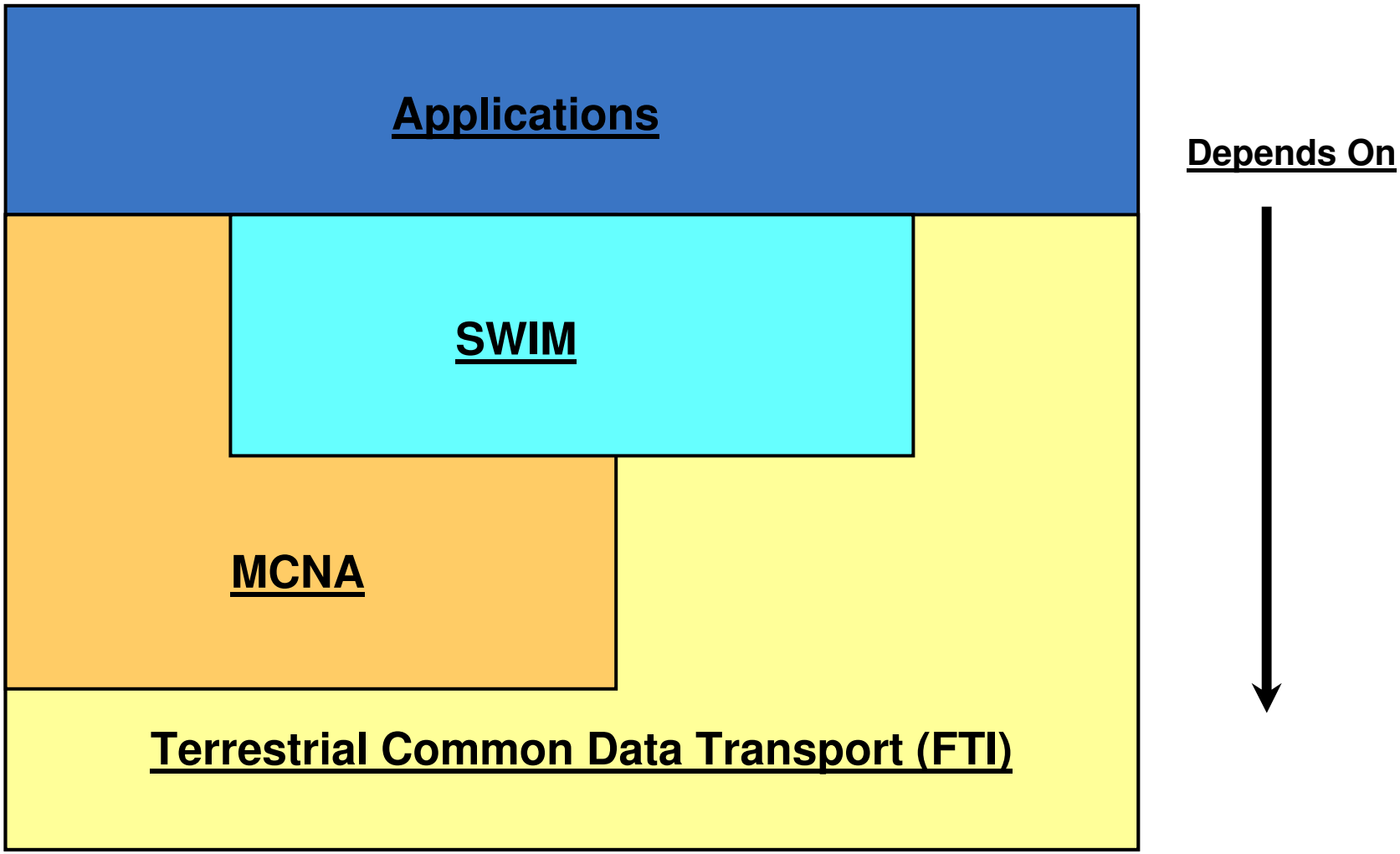
To accomplish this SWIM provides mechanisms for:

- ***Finding and accessing information sources,***
- ***Registering and advertising interfaces, schemas and data definitions,***
- ***Securing information and services, and,***
- ***Managing all of these items.***

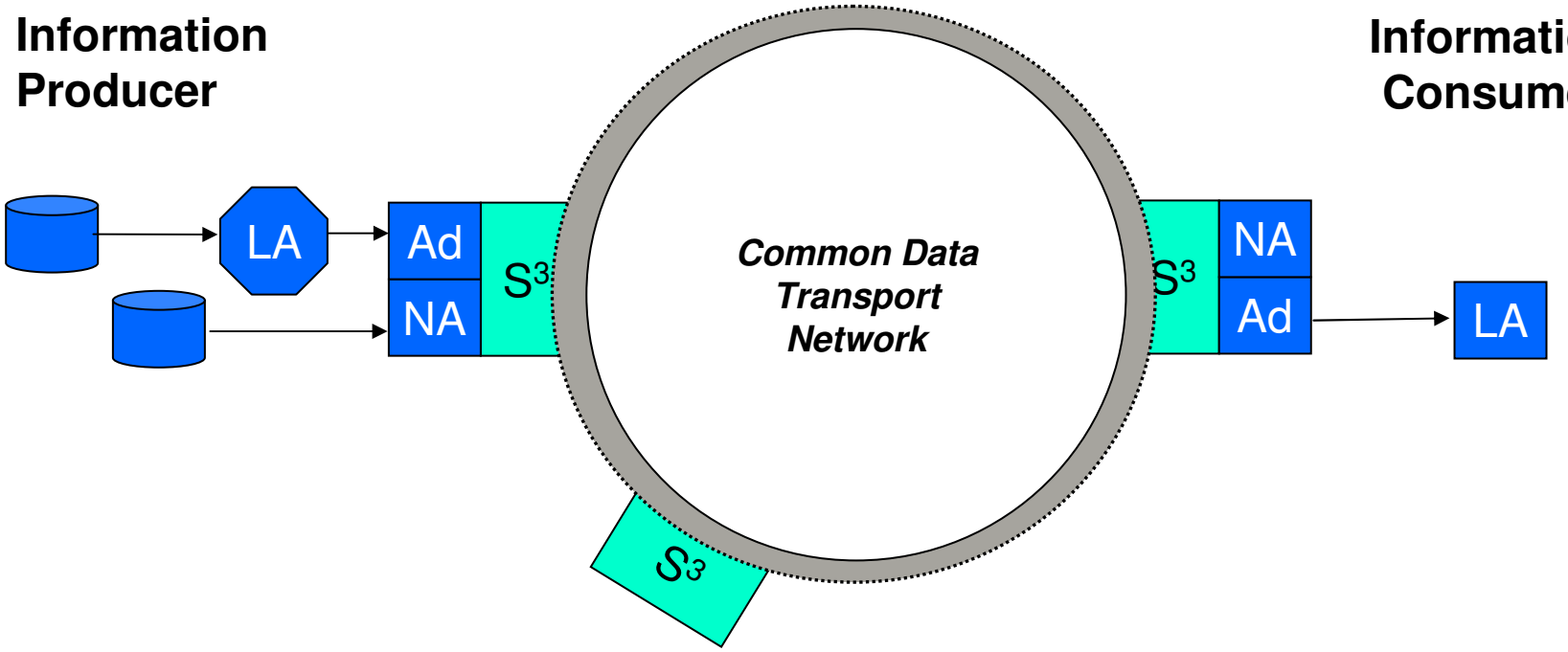
SWIM Core & Value-Added Services



SWIM, MCNA, CDT Dependencies



SWIM Reference Model



SWIM Element

Applications Element

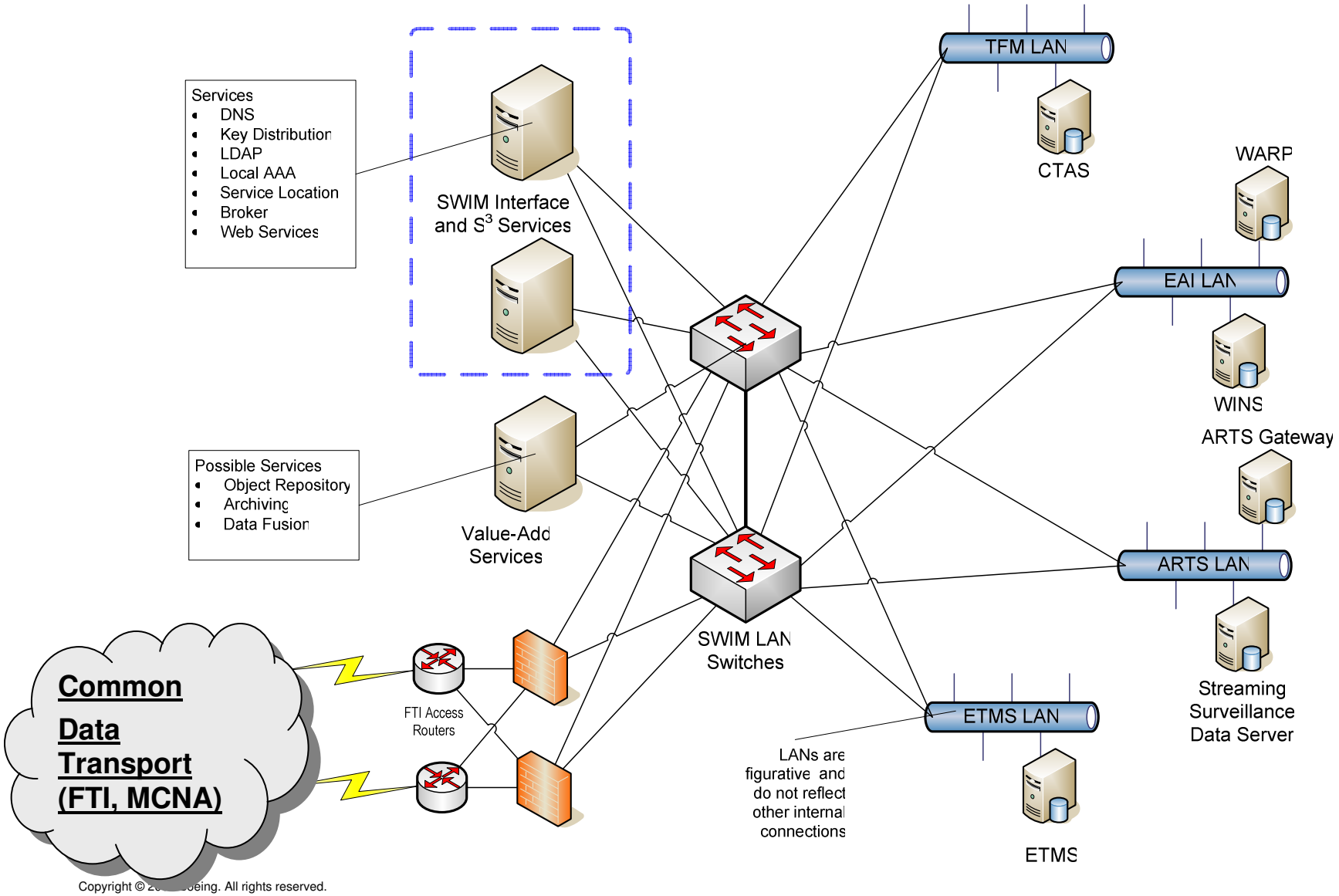
S³ – SWIM Shared Services

NA – Native Application

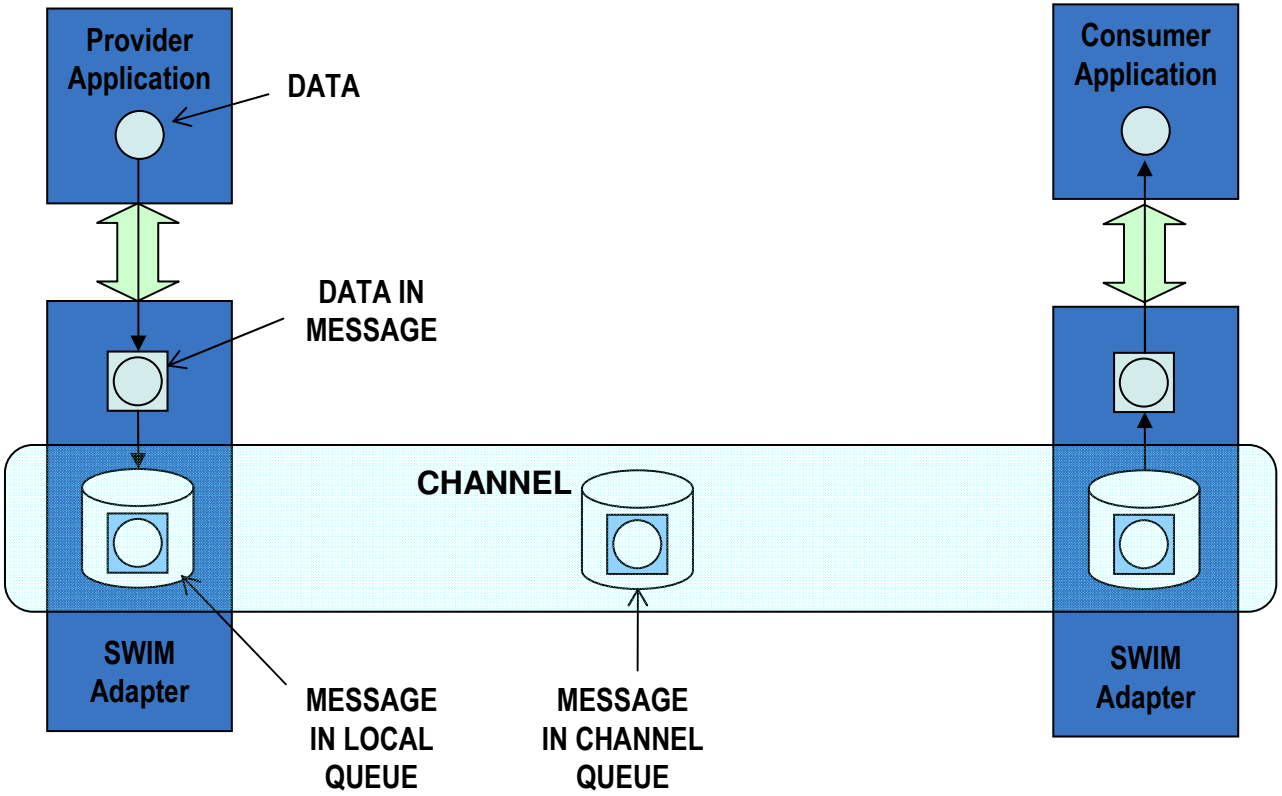
LA – Legacy Application

Ad – Adapter

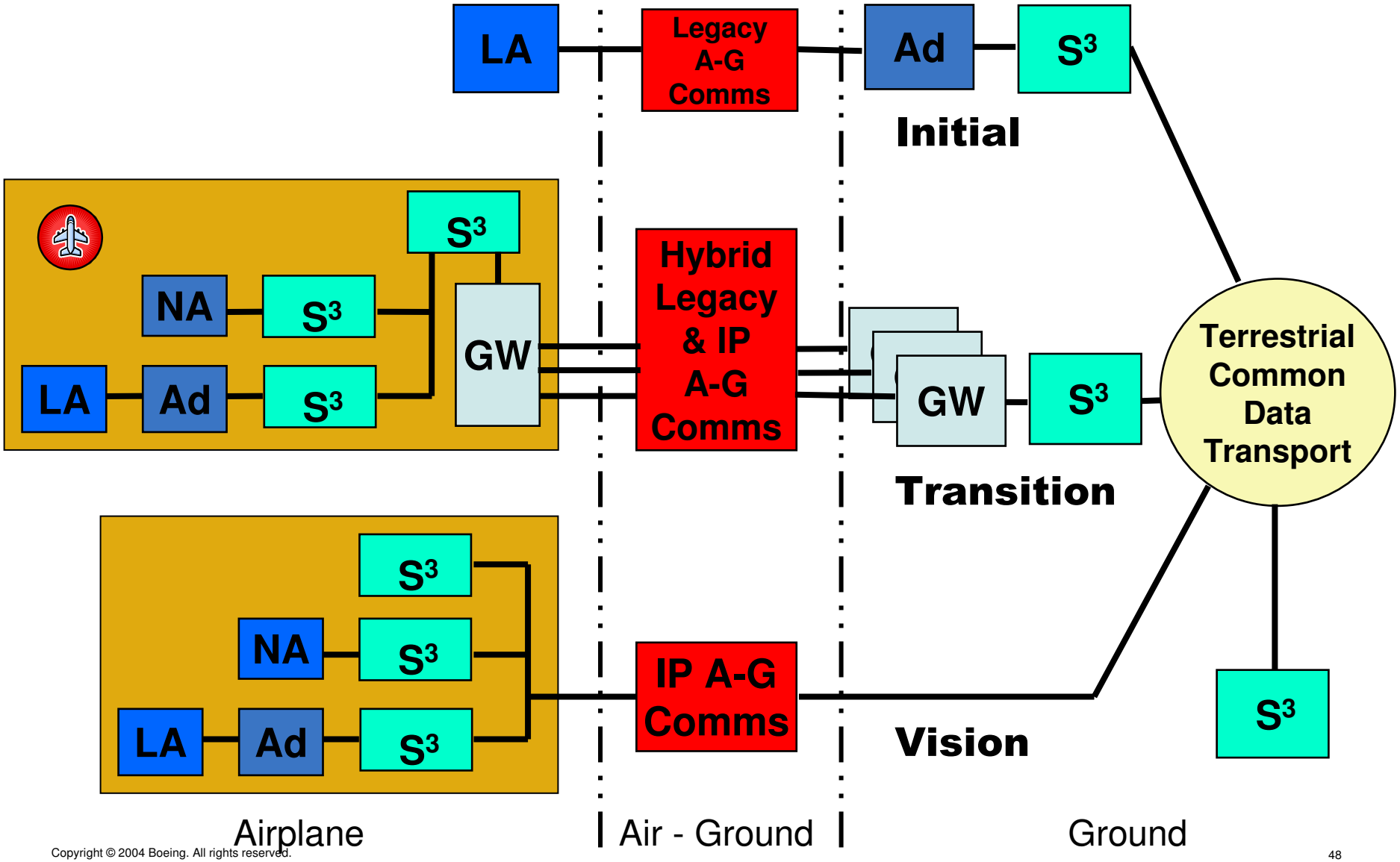
Spiral 1 ARTCC SWIM Connectivity



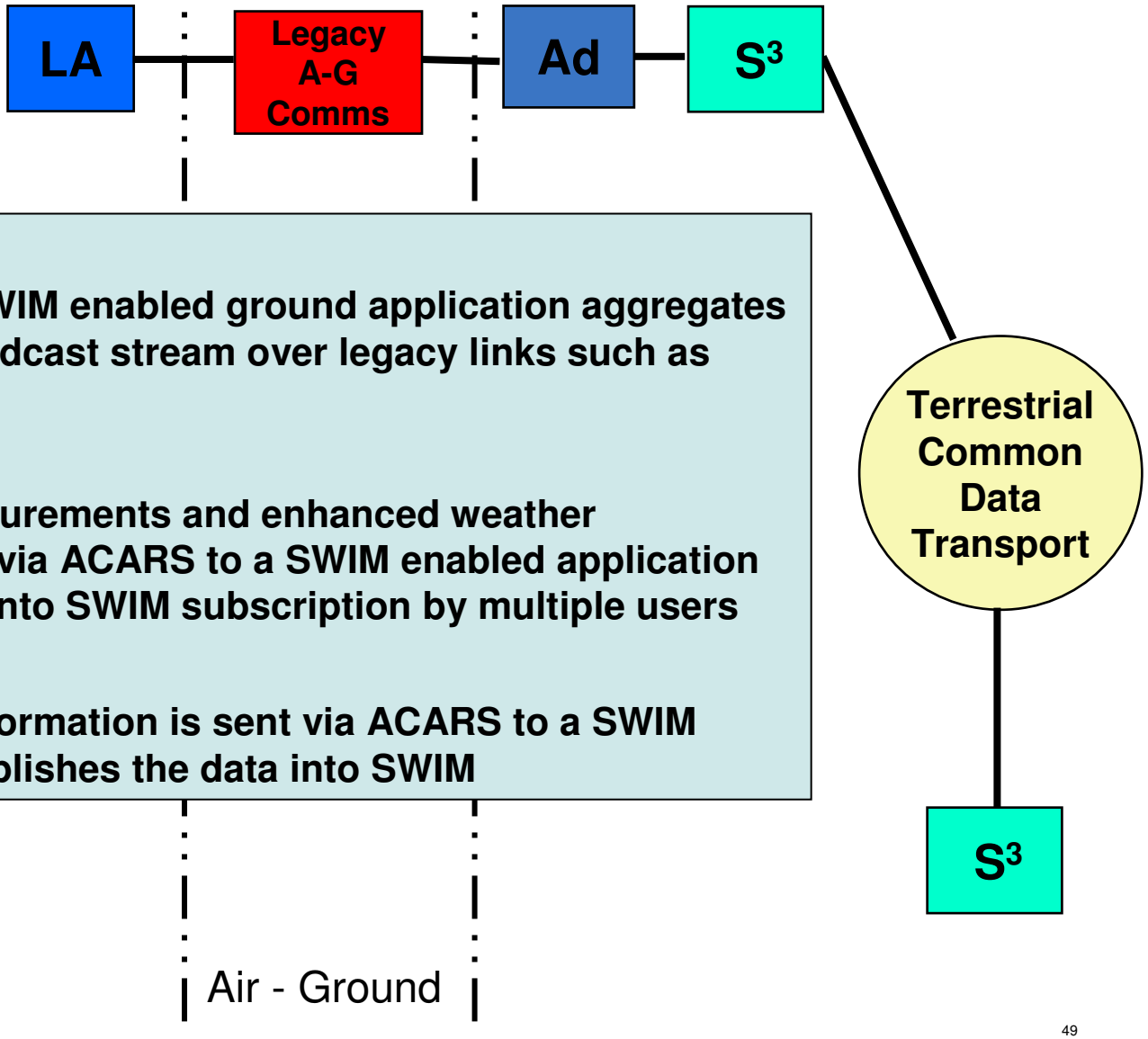
SWIM Messaging Process



MCNA/SWIM Nodes – Implementation Options



MCNA/SWIM Nodes – Initial Transition



Examples:

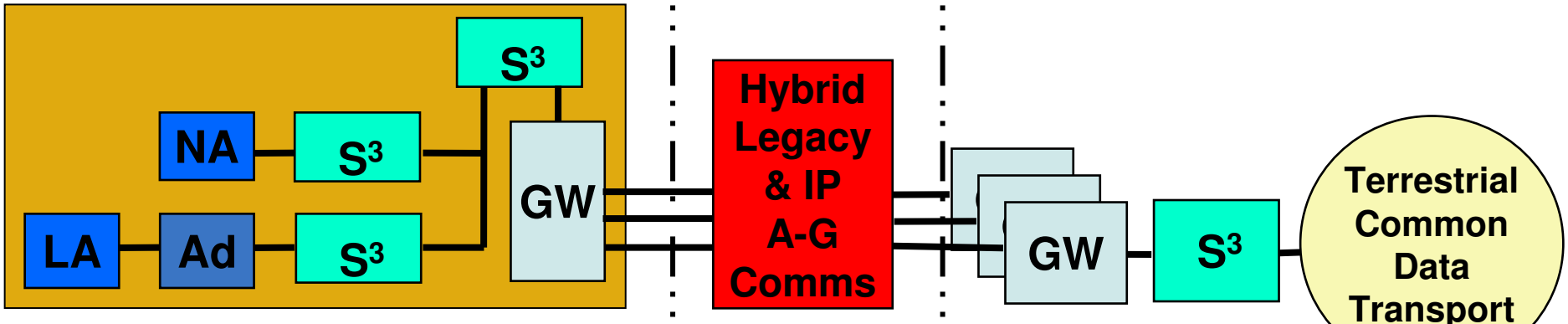
Broadcast Services – SWIM enabled ground application aggregates data and generates broadcast stream over legacy links such as UAT, 1090ES or VDL-B

MDCRS – Weather measurements and enhanced weather measurements are sent via ACARS to a SWIM enabled application that publishes the data into SWIM subscription by multiple users

OOOI – Aircraft state information is sent via ACARS to a SWIM enabled adapter that publishes the data into SWIM

MCNA/SWIM Nodes – Transition

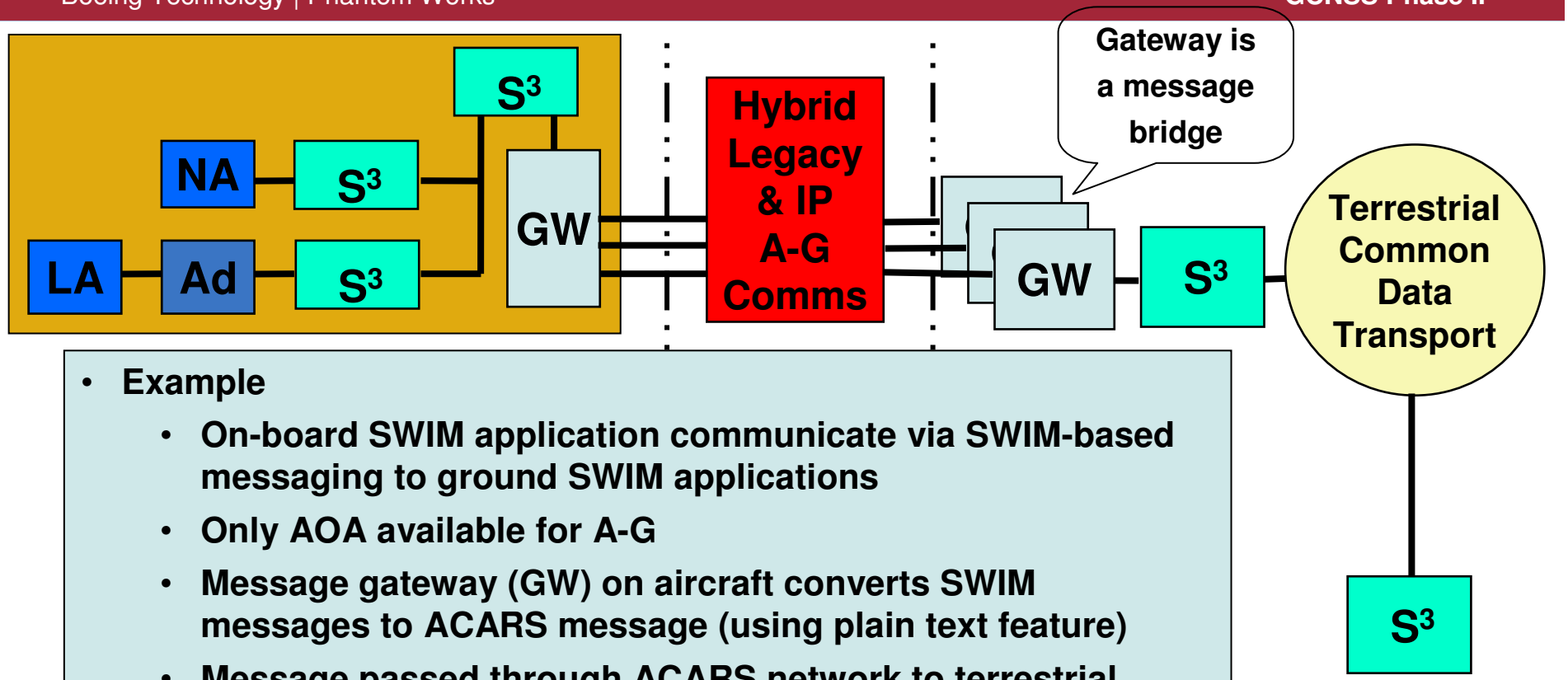
- IP, ATN or ACARS connection from terrestrial CDT to aircraft
- Legacy airplane apps require a SWIM enabled adapter
- New apps can be developed natively SWIM enabled



- On-board SWIM broker provides additional capabilities to minimize unnecessary usage of A-G resources
  - Information caching
  - Local registry of SWIM service available on the aircraft
- Adapters at the air and ground might provide: compression, tunneling, protocol conversion, etc.

Airplane | Air - Ground

MCNA/SWIM Nodes – Transition (continued)

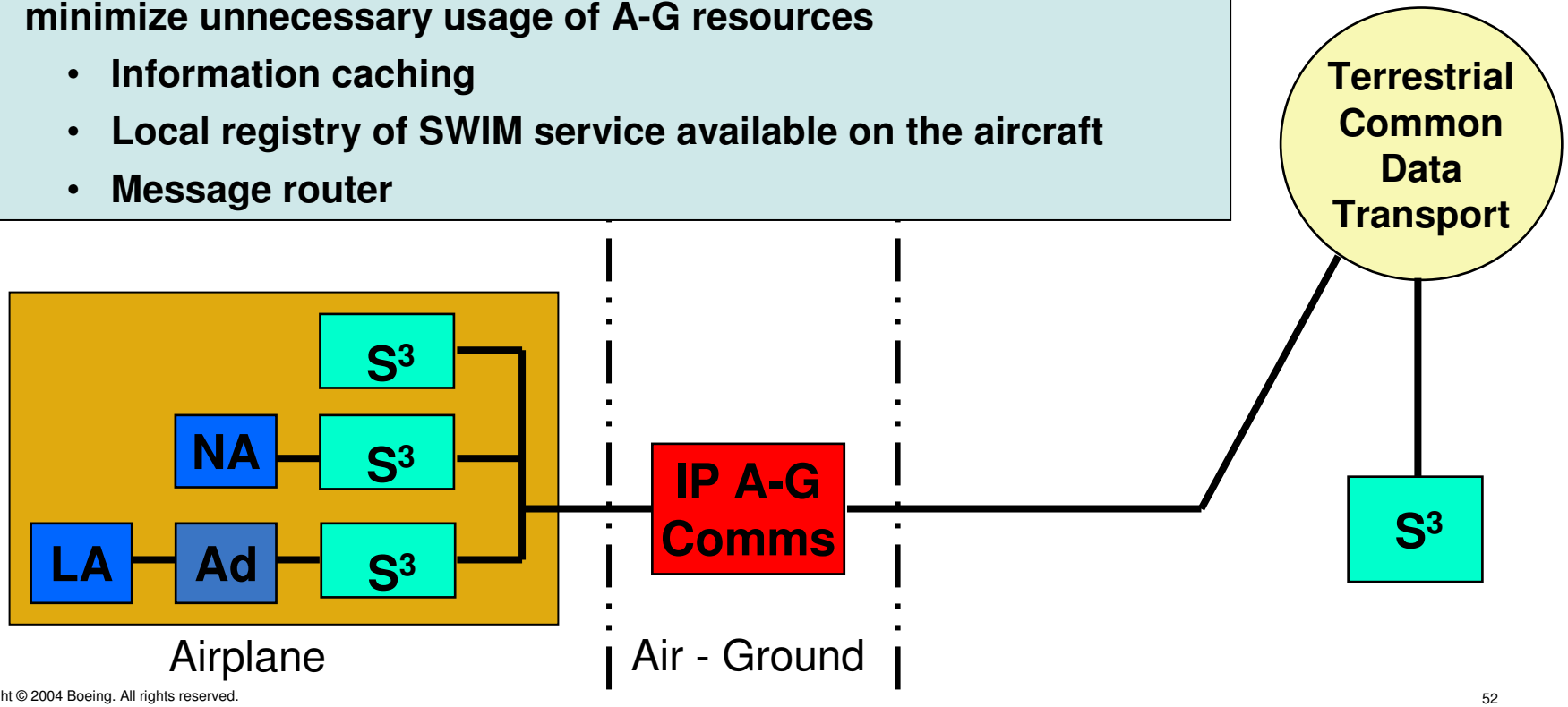


- **Example**
  - **On-board SWIM application communicate via SWIM-based messaging to ground SWIM applications**
  - **Only AOA available for A-G**
  - **Message gateway (GW) on aircraft converts SWIM messages to ACARS message (using plain text feature)**
  - **Message passed through ACARS network to terrestrial message gateway**
  - **SWIM message extracted from ACARS message and forwarded into SWIM**
  - **Response message follows the inverse path**

Airplane | Air - Ground

MCNA/SWIM Nodes – Vision State

- IP connection from terrestrial CDT to aircraft
- IP A-G is an extension of CDT
- Legacy airplane apps require a SWIM enabled adapter
- New apps can be developed natively SWIM enabled
- On-board SWIM broker provides additional capabilities to minimize unnecessary usage of A-G resources
  - Information caching
  - Local registry of SWIM service available on the aircraft
  - Message router



Avionics Architecture

Aloke Roy
MCNA Final Briefing
15 August 2005

Objective and Scope

- **Assess the current state of avionics architectures**
  - **Fielded avionics systems**
  - **Current trends toward network-centric, IP-based avionics**
- **Define a vision-state avionics architecture**
  - **Facilitates network-centric Air Traffic Management (ATM)**
  - **Permits use of Internet Protocol (IP) and commercial networks**
  - **Identify technology gaps, risks, and potential mitigation strategies**
- **Identify transition issues and operation with mixed avionics architectures**
- **Recommend standardization actions necessary to support the vision-state architecture**

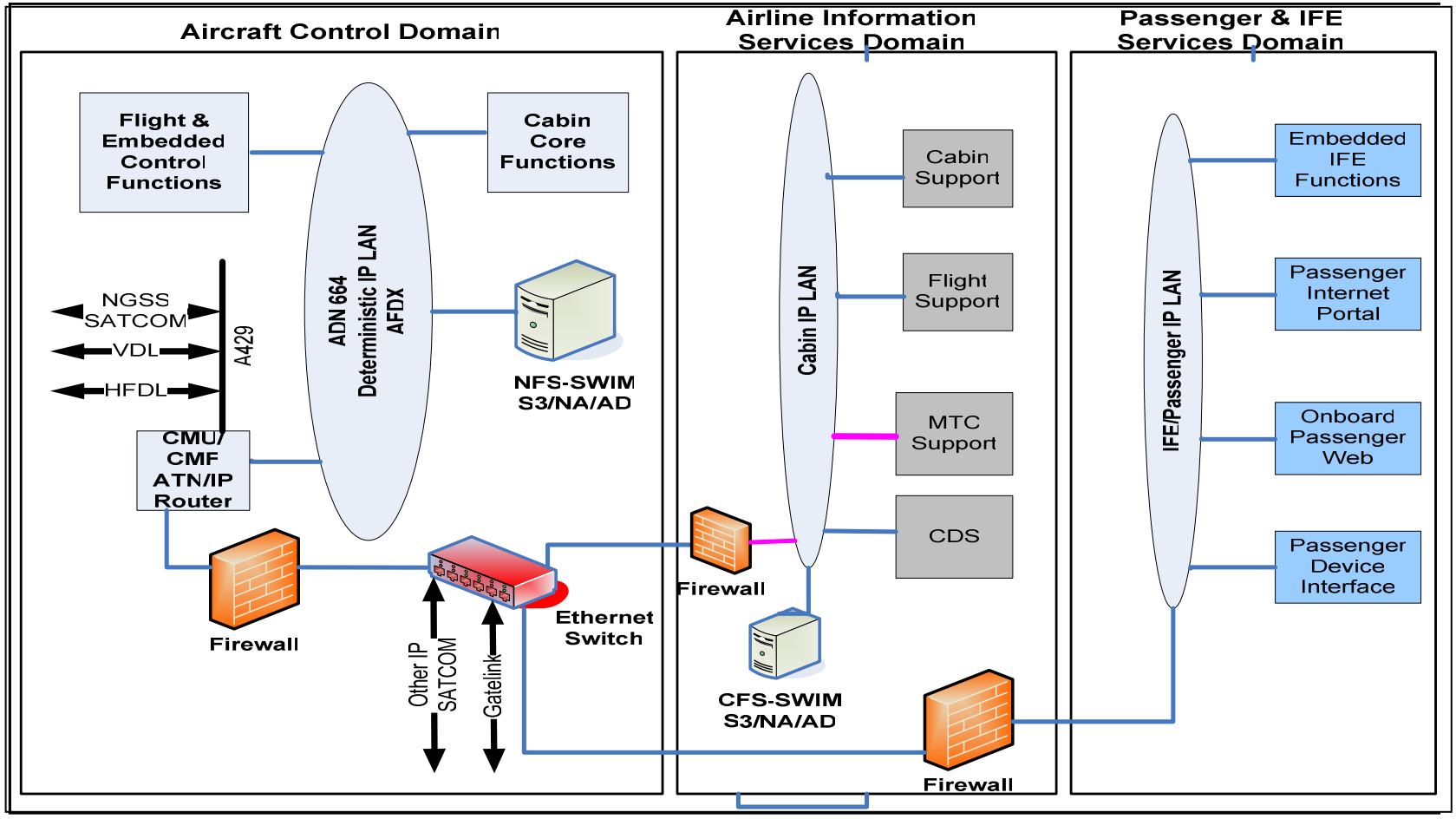
Architecture Highlights [1 of 2]

- **Based on the domain model specified in ARINC 664 - Aircraft Data Network**
- **Allocates SWIM functionalities to airborne file servers**
  - **Dedicated servers in ACD and AISD to support domain specific applications having different QoS and criticality levels**
  - **Isolation of SWIM functions across domain boundaries reduces system vulnerability**
  - **SWIM Adapters integrated with file servers to support legacy applications**
- **Leverages avionics integration and reusable, software defined components to reduce certification costs**

Architecture Highlights [2 of 2]

- **On-board network connectivity provided by IP**
  - **Profiled IP network, such as AFDX, for ACD**
  - **Standard IP network for AISD**
- **Air/Ground network**
  - **Adopts commercial IP networks for ATM using Required Communication Performance (RCP) standards**
  - **Uses Firewalls and cryptographic schemes to serve applications with different criticality levels and to prevent unauthorized access**
  - **Router located in ACD manages network resources to meet QoS requirements**
  - **Legacy ICAO-specified networks supported by ACD**

Vision State Avionics Architecture



Future Work & Recommendations [1 of 2]

- **Perform cost/benefit analysis to trade single on-board network versus isolated networks for ACD and AISD**
- **Develop specifications to address the technology gaps in IP protocol suite to meet aeronautical requirements**
  - **Mobility management, congestion control, QoS,**
  - **Security policies, procedures for mobile environment**
  - **Global addressing scheme consistent with ICAO & commercial network practices**
- **Simplify avionics and MCNA certification process**
  - **Reduce integrated avionics development and certification costs through reuse of software defined components**
  - **Needed to adopt current and future commercial networks**
  - **Develop RCP specifications**

Future Work & Recommendations [2 of 2]

- **Develop incremental deployment roadmap**
  - **Enhancement to MCNA technology roadmap deliverable**
  - **Used to obtain buy-in and commitment from stakeholders**
  - **Incremental steps lowers initial investment while maximizing benefits to generate sufficient ROI**
  - **Accommodates technological advancements and validation of benefits**
- **Coordinate the development of IP standards to ensure consistency across aeronautical standards committees**
  - **SWIM requirements need to be addressed immediately within AEEC ADN, CFS and NFS standards**

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Certification Report Summary

E. F. C. LaBerge
MCNA Final Briefing
15 August 2005

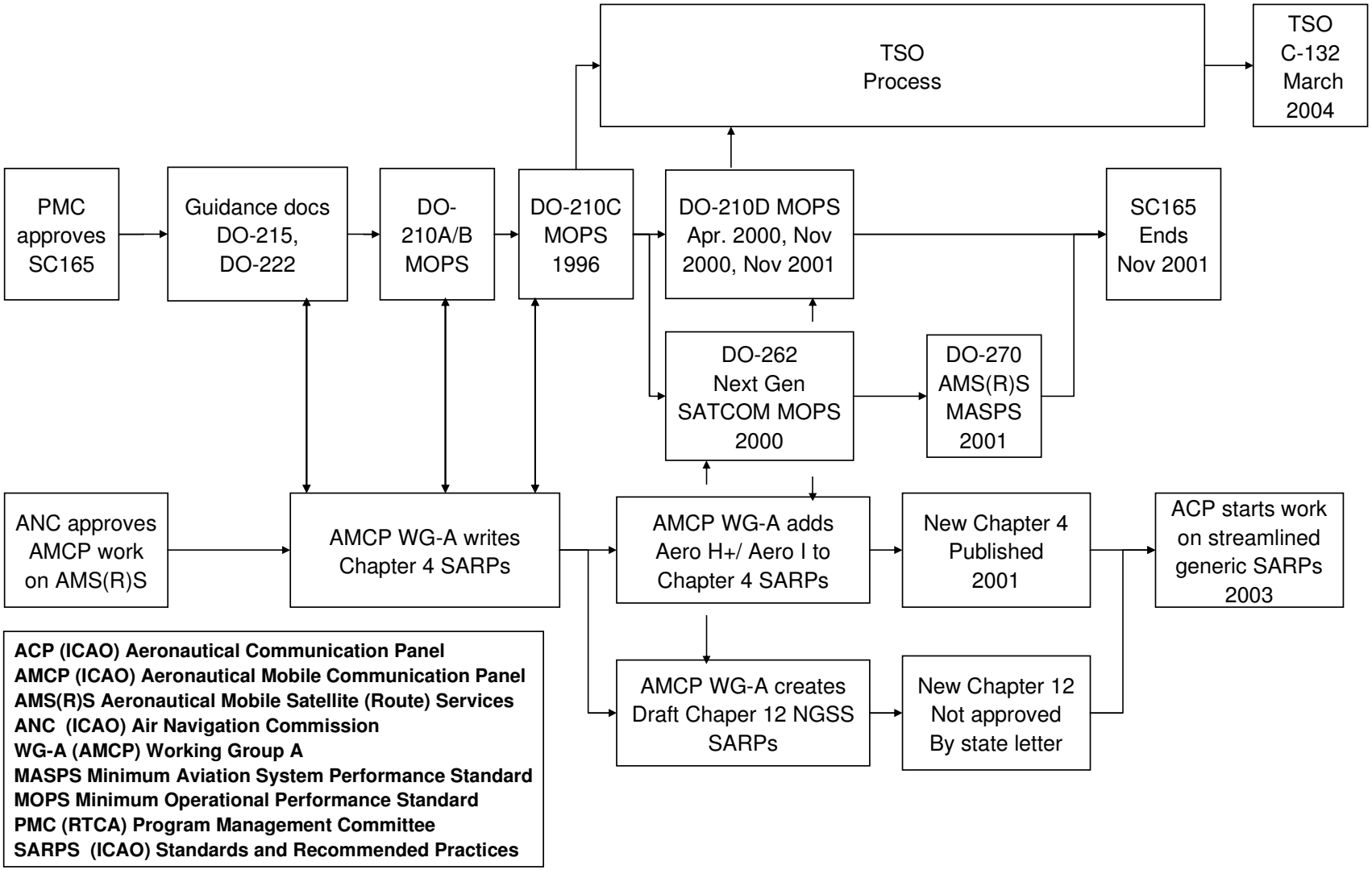
What is “certification”

- Report uses “certification” in the broadest sense
- Full range of approval activities
  - Functional approval of the avionics (TSO, PMA, etc)
  - Granting aircraft Type Certificate or Supplemental Type Certificate
  - Operational approval of the aircraft
  - Acceptance/approval of air-ground communication *system*
- Report organized around three approval processes
  - System approval
  - Avionics approval
  - Aircraft approval
- *System* approval is the thorny issue

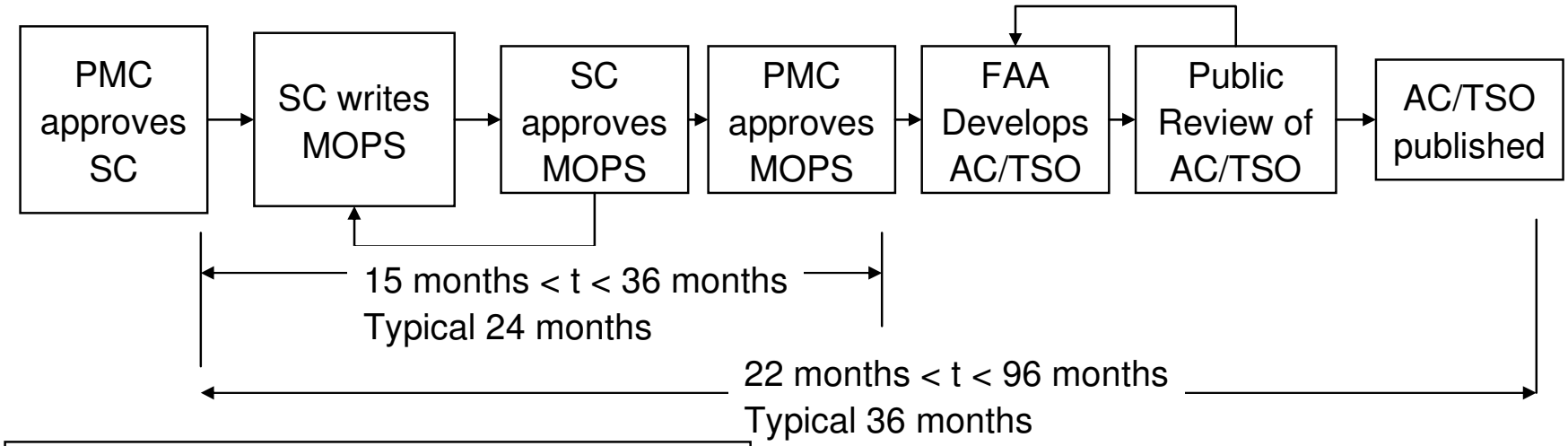
Current Process

- System approval
  - No standard process for approval of new communications system for Aeronautical Operational Control (AOC) or Air Traffic Services (ATS)
  - Two commercial systems are commonly uses for AOC+
    - Aircraft Addressing and Reporting System (ACARS)
    - INMARSAT Aero H family
- Avionics Approval
  - Minimum Operational Performance Standards (MOPS)
    - DO-262 MOPS for Next Generation SATCOM Systems might provide guidance
  - Parts Manufacturing Authorization (PMA)
  - Technical Standard Order
- Aircraft Approval
  - TC and STC processes well understood

Current processes are cumbersome…



…and time consuming

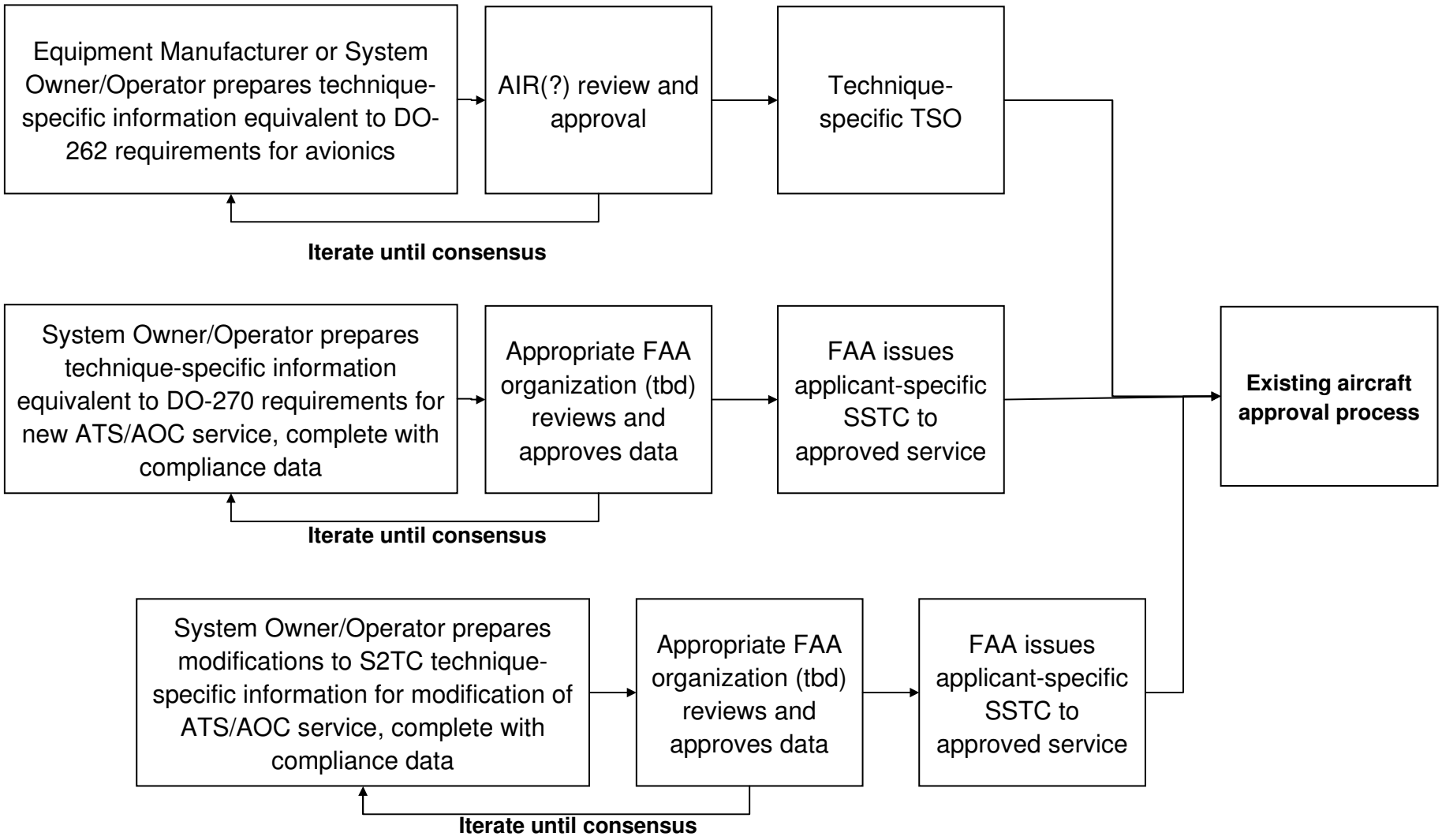


AC (FAA) Advisory Circular
FAA Federal Aviation Administration
MOP Minimum Operational Performance Standards
PMC Program Management Committee of RTCA
SC Special Committee
WG Working Group

Visionary Process

- System Approval
  - System/Service Type Certificate (SSTC or S2TC)
  - System/Service Supplemental Type Certificate (SSSTC or S3TC)
  - DO-270 MASPS for Next Generation SATCOM Systems might provide a template
  - INMARSAT Swift Broadband example
- Avionics Approval
  - DO-262 MOPS for Next Generation SATCOM Systems might provide guidance
  - Parts Manufacturing Authorization (PMA)
  - Technical Standard Order
- Aircraft Approval
  - TC and STC processes well understood

Visionary process flow



Conclusions and recommendations

- **Conclusion 1: No formal FAA process for *system* approval**
  - **Recommendation 1: Develop system approval process (FAA and interested parties)**
  - **Recommendation 2: Undertake development and validation of a data package based on DO-270 (FAA and specific applicant)**
- **Conclusion 2: No widely accepted model for use of commercial terrestrial infrastructure in FAA safety communications**
  - **Recommendation 3: Study how use commercial *wired* infrastructure differs from commercial *wireless* infrastructure and feed results to Recommendation 1. (FAA/NASA)**

Conclusions and recommendations

- **Conclusion 3: No FAA process for approval of avionics for use with commercial infrastructure**
  - **Recommendation 4: Develop agreed-upon submission process for avionics information based on DO-262. (FAA and specific applicant)**
  - **Recommendation 5: Develop means to expedite certification of commercial software (SC-205, FAA, NASA)**
  - **Recommendation 6: Fund development of certifiable IP stack (FAA / NASA).**
- **Conclusion 4: Current aircraft certification process may need revision for RCP applications**
  - **Recommendation 7: Develop details of RCP certification/approval process (PARC?, FAA, NASA)**

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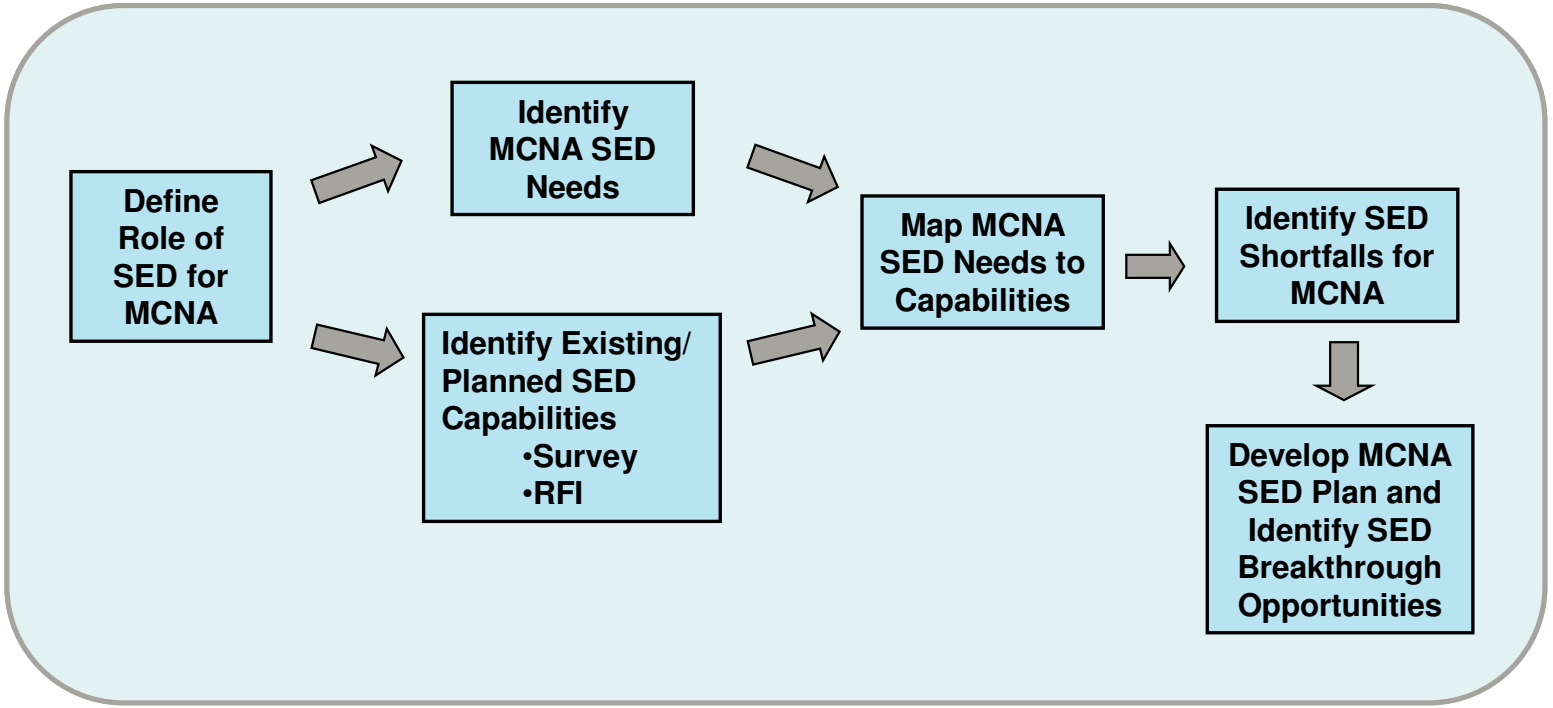
MCNA
Simulation, Emulation, and Demonstration Capability Planning

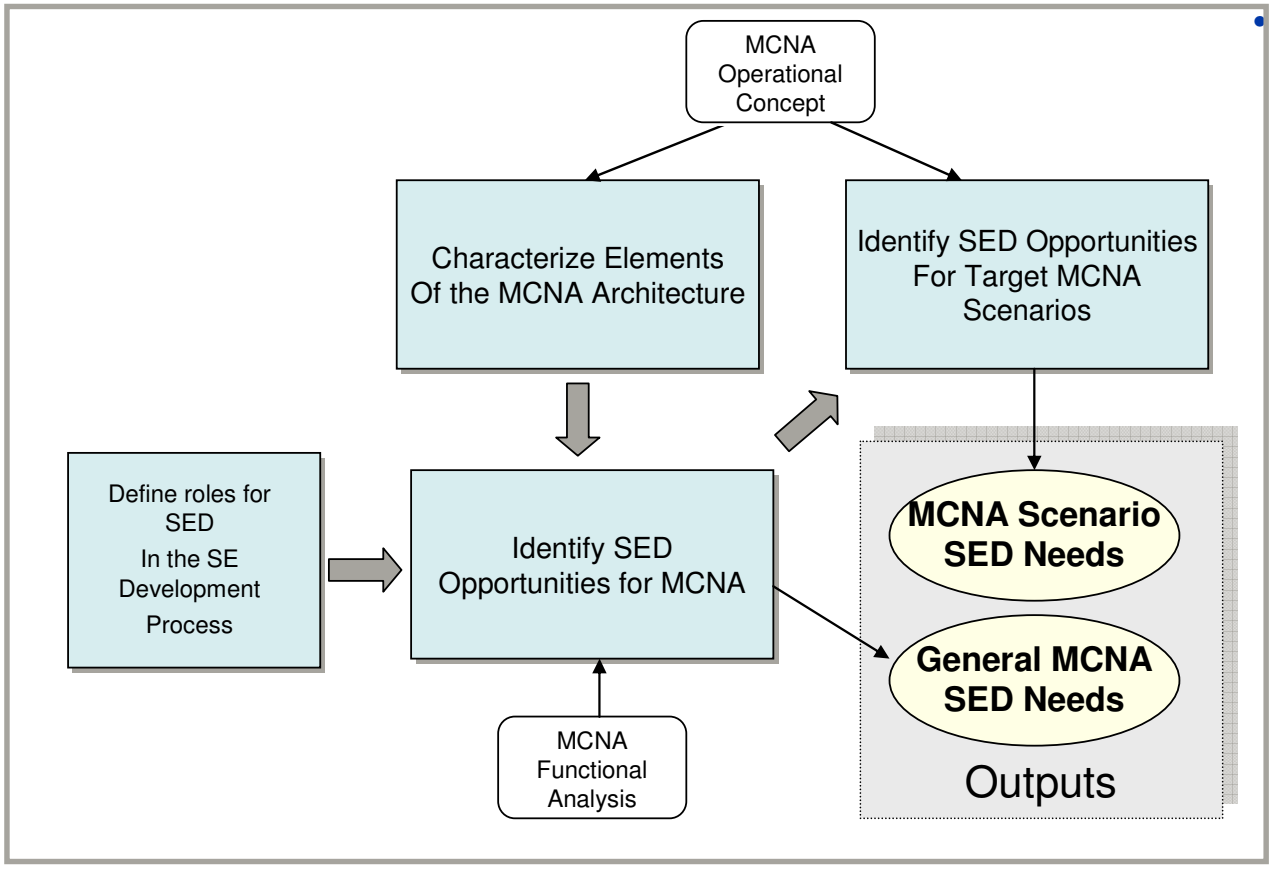
ITT Industries
MCNA Final Briefing
15 August 2005

Simulation, Emulation, Demonstration (SED) Task Objectives and Flow

- **Identify candidate SED models/tools to validate MCNA concepts, strategies and enabling technologies**
- **Define SED plans for targeted development or enhancement of models/tools to validate MCNA performance and operational scenarios**
- **Identify and develop concepts for demonstrations of capabilities enabled by MCNA**



Identifying SED Needs



- SED needs categories
  - System Components
    - RF Link Components
    - Ground Network Components
    - Avionic Network Components
  - System Interfaces/Interactions
    - Protocol interactions (A/G to G/G; alternate G/G to G/G; A/A to A/G
    - Ground element interactions
    - SWIM/MCNA interactions
  - System-of-System Operations
    - Voice Services
    - Data Services

Key SED Needs for MCNA

- Simulation models for existing and future A/G communication links
- Simulation models for existing ATM ground networks (e.g. ACARS, ATN)
- Algorithms and simulation models for architectures that accommodate dynamic routing across multiple communication links
- Simulation tools that can accommodate modeling of mobility protocols (e.g. mobile IP)
- Capability to emulate ATC operations associated with target MCNA scenarios
- Capability to simulate and emulate avionics architectures to accommodate target MCNA scenarios
- Capability to demonstrate use of mobility protocols and dynamic routing

Identifying Existing/Planned SED Capabilities

- A three step approach was used to identify existing and planned SED capabilities suitable for the MCNA
  - Internet search of general industry and Government aeronautical MCNA related SED capabilities
  - Feedback to the results of the Internet search by MCNA/GCNSS Phase II team members
  - A more specifically targeted NASA GRC released Request for Information (RFI)
- Over 150 SED capabilities were identified

RFI Responses

- **In January 2005 NASA GRC released an RFI entitled "Aeronautical Mobile Communication Network Architecture (MCNA) Simulation, Emulation and Demonstration Capabilities."**
- **There were ten responses to the RFI:**
  - BoozAllenHamilton
  - Calian – SED Systems
  - NASA Glenn Research Center & Computer Networks and Software, Inc
  - Mulkerin Associates Inc and Computer Networks & Software, Inc.
  - Lucent Technologies Inc.
  - NASA Ames Research Center
  - Ohio University
  - Seagull Technology, Inc.
  - Sensis Corporation

Mapping of SED Needs to Capabilities

- Many identified SED capabilities were determined to be duplicative, non-pertinent, or capabilities that were too generalized
  - These were eliminated from further consideration
- Remaining SED capabilities were organized into major tool categories to simplify the process of mapping SED capabilities to MCNA needs
  - RF SED & Planning Tools
  - OPNET Models
  - Tower Simulation/Target Generation/ATC
  - Virtual Airspace Modeling and Simulation (VAMS) related
- The identified SED tools were then mapped to the three major SED needs categories: System Components, System Interfaces/Interactions, and System-of-System Operations

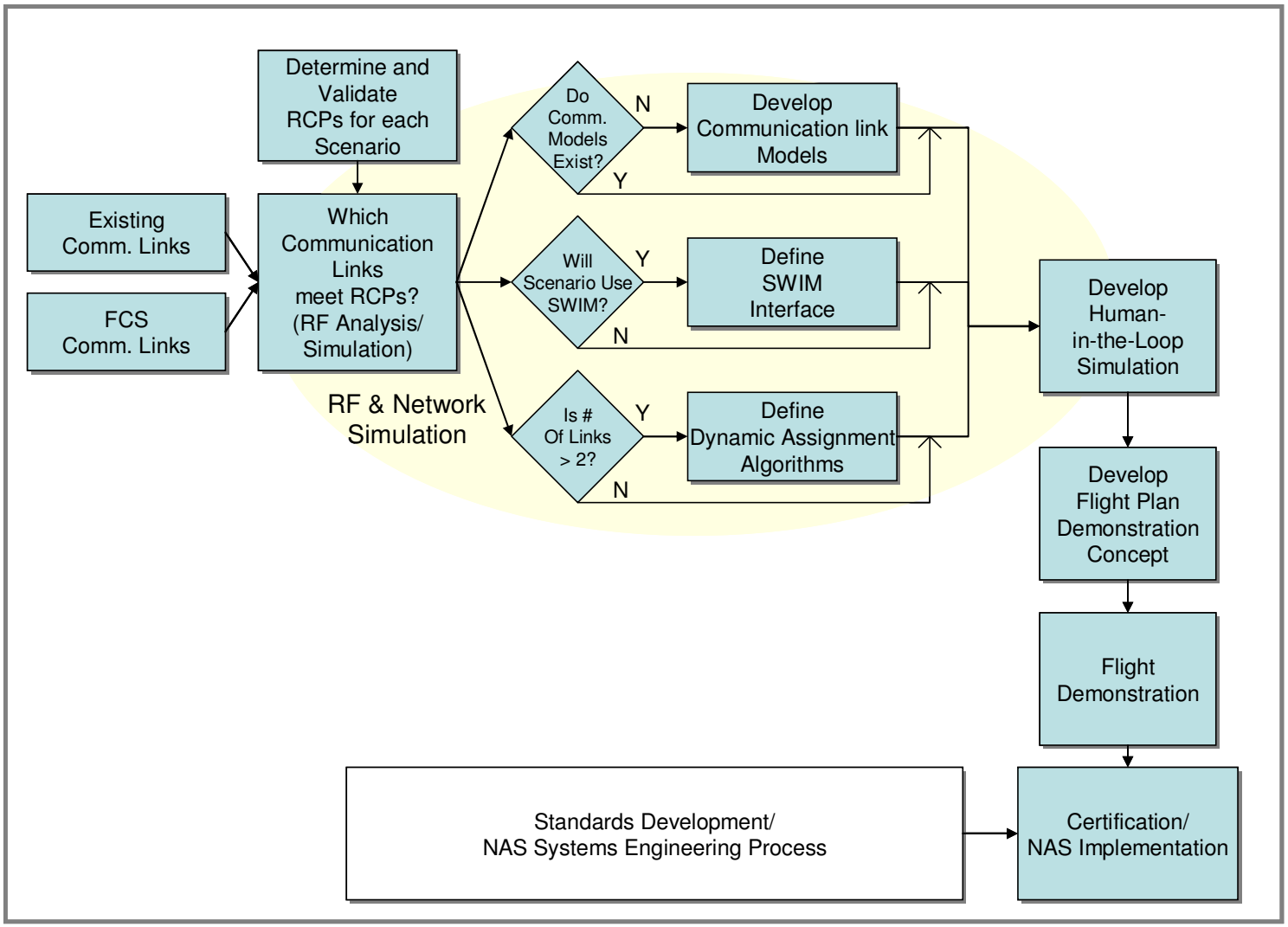
Mapping of SED Needs to Capabilities

- Several Tools-to-Needs Mapping Matrices were created
  - Three general MCNA matching matrices were first created
    - Mapping of SED Tools to MCNA Needs for 1) Individual Systems, 2) System Interfaces/Interactions, and 3) System-of-Systems Operations
  - To further focus the tools-to-needs mapping, a mapping of tools that may contribute to the satisfaction of the key general SED needs was generated
  - Finally, a mapping of tools to needs specific to the target MCNA operational scenarios was developed

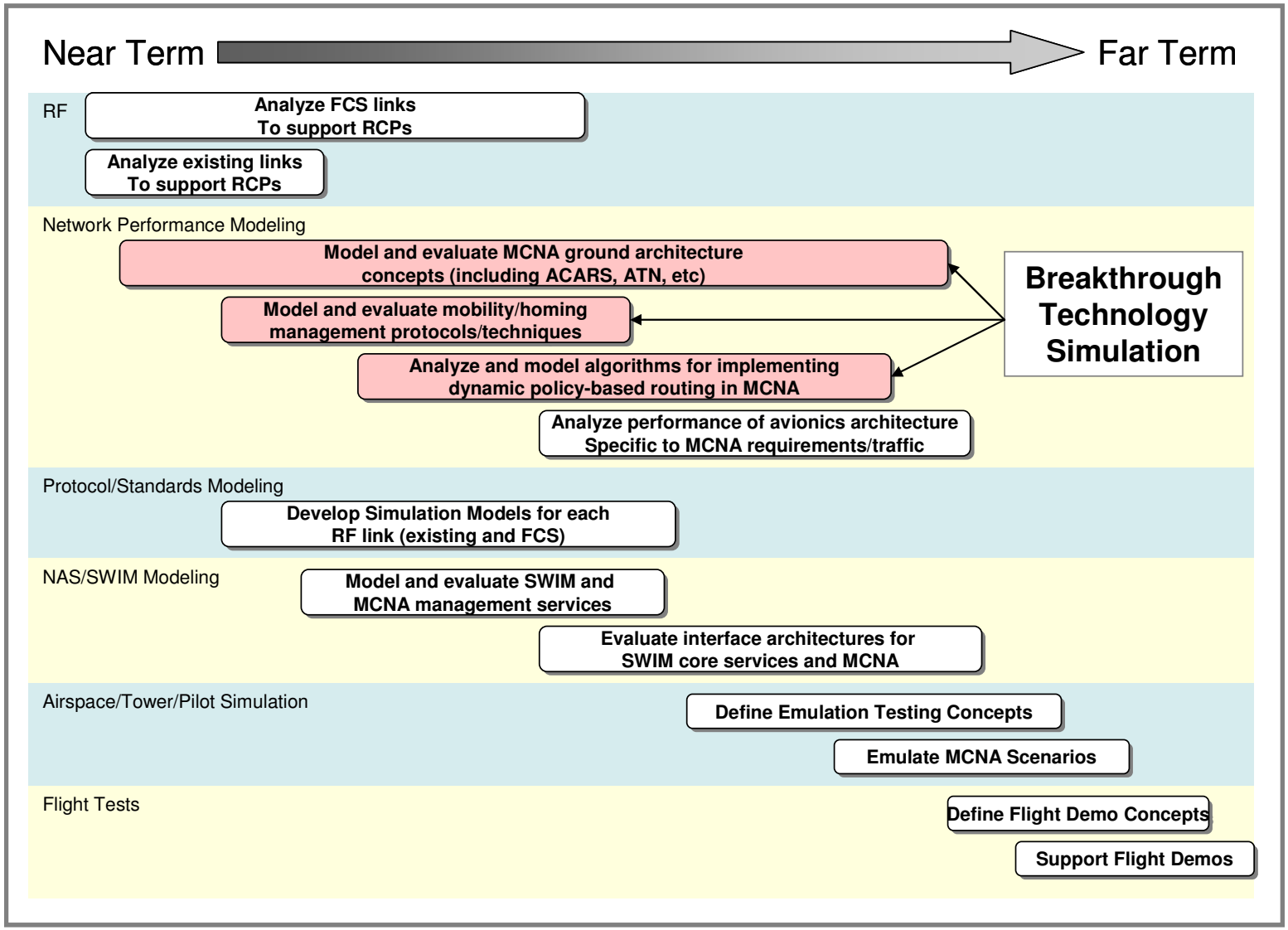
SED Shortfalls for MCNA

- Several significant SED gaps for MCNA were identified
  - Insufficient tools to simulate dynamic routing of MCNA data over multiple weighted communication links (e.g. implementation of mobility management, policy-based routing, etc. in an aeronautical environment)
  - Insufficient models/tools for analyzing existing ATM ground networks (e.g. ACARS, ATN)
  - Insufficient models/tools to analyze full complement of existing and future NAS RF links
  - Insufficient models/tools for evaluation of SWIM interfaces to MCNA and implementation of SWIM core services within the MCNA architecture
  - Insufficient integration of simulation models for RF and ground network with operation modeling/emulation tools
  - Insufficient integration of various RF simulation models/tools needed to support exploration of the MCNA system-of-systems concept
  - Insufficient model/emulation environments for avionics architectures
  - Insufficient capabilities/tailored applications within emulation environments to evaluate target MCNA scenarios

Generating the MCNA SED Plan



MCNA Simulation, Emulation, Development Plan



Breakthrough SED Opportunity for MCNA

- **A breakthrough SED opportunity for MCNA was identified**
  - Implementation of simulation and demonstration capabilities to validate/demonstrate network centric operations of integrated A/G and aeronautical ground networks to extend SWIM capabilities to the aircraft
  - This concept incorporates mobility management and dynamic routing features within multiple aeronautical ground networks with interfaces to multiple A/G links to the aircraft.

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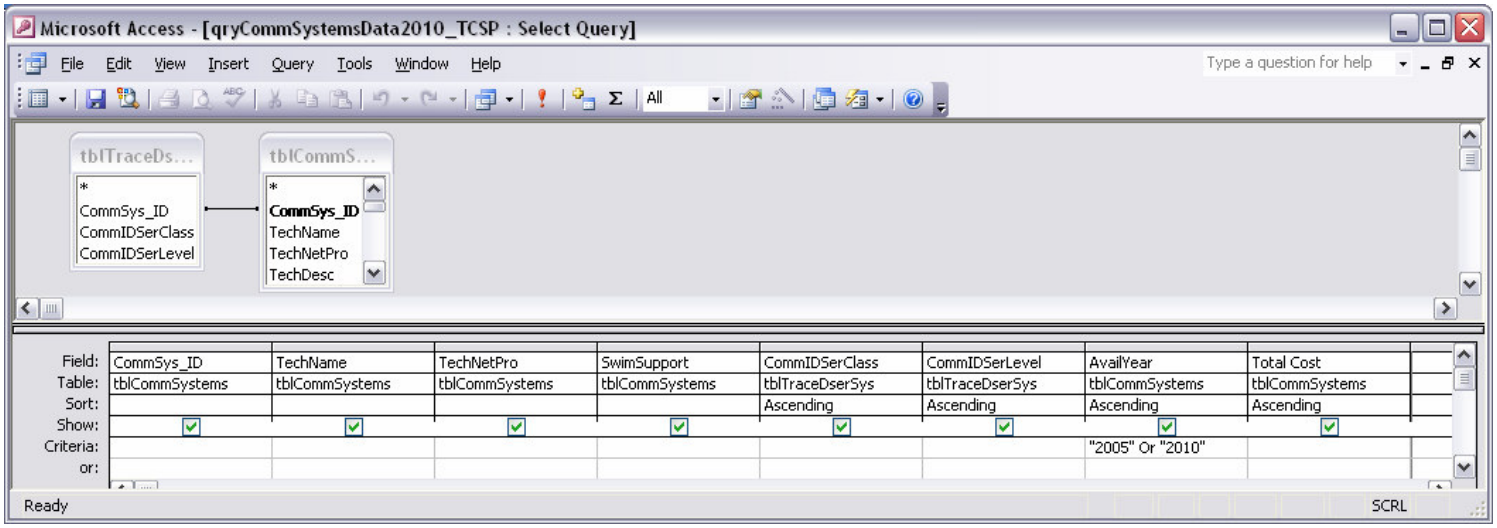
Transition Analysis

Karl Griep
MCNA Final Briefing
15 August 2005

MCNA Transition Analysis

- **Goal: Develop concepts for transition and strategies for interoperability with existing and planned NAS infrastructure**
- **Total Communication System Performance**
  - **Evolution of MCNA functionality over time**
  - **Based on roll out of MCNA communication service classes over time**
  - **Broken out into two different views**
    - **Airspace Domains**
    - **Aircraft Classes**
- **Representative Transition Paths**
  - **Based on High Benefit/Cost MCNA Operational Scenarios**
  - **Graphical Representation of how Communication Systems Provide Communication Services that support operational scenarios**

Candidate Link Technologies Mapped to Services



OUTPUT

CommSys_ID	TechName	TechNetPro	CommIDSerClass	mIDSerL	AvailYea	Total Cost
22	1090ES	CLNP	Air to Air Data	1	**2010**	1
25	VDLm4	CLNP	Air to Air Data	1	**2010**	3
17	Swift Broadband	IP	Air to Ground Data	1	**2010**	5
16	Swift 64	IP	Air to Ground Data	3	2005	7
21	Connexion by Boeing	IP	Air to Ground Data	3	2005	9
5	VDLm2	CLNP	Air to Ground Data	3	**2010**	3
31	IEEE 802.11	IP	Air to Ground Data	3	**2010**	4
6	VDLm2	IP	Air to Ground Data	3	**2010**	6
23	1090-ES	Layer-2	Broadcast from Aircraft	1	2005	1
25	VDLm4	CLNP	Broadcast from Aircraft	1	**2010**	3

Total Communication System Performance Levels

Confidence

- High
- Medium
- Low

Service Levels

- NA — Not Available
- 1 — Most Stringent
- To
- 4 — Least Stringent

		Communication Service Class	Airspace Domains							Aircraft Classes					
			Gate	Surface	Terminal	En Route	Remote	Oceanic	Polar	Transport	Cargo	Business Jet	GA	Military	UAV/ROA
2005	Voice	Party Line Voice	1	1	1	1	NA	NA	NA	1	1	1	1	1	NA
		Selective Addressed Voice	NA	NA	NA	2	2	2	NA	2	2	2	3	2	NA
		Broadcast Voice	1	1	1	1	NA	NA	NA	1	1	1	1	1	NA
	Data	Data Messaging	3	3	3	3	2	2	3	2	2	NA	NA	NA	NA
		Trajectory Exchange	NA	NA`	NA	NA	2	2	NA	2	2	NA	NA	NA	NA
		Broadcast to Aircraft	NA	3	3	3	NA	NA	NA	3	3	3	3	NA	NA
		Broadcast from Aircraft	NA	NA	NA	NA	NA	3	NA	3	3	NA	NA	NA	NA
		Ground to Air Data	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Air to Ground Data	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Air to Air Data	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Video Exchange	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Command and Control	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2005-2010	Voice	Party Line Voice	1	1	1	1	4	4	NA	1	1	1	1	1	3
		Selective Addressed Voice	2	2	2	2	2	2	3	2	2	2	NA	2	NA
		Broadcast Voice	1	1	1	1	1	1	NA	1	1	1	1	1	1
	Data	Data Messaging	2	2	2	1	1	1	3	1	1	1	NA	NA	NA
		Trajectory Exchange	2	2	2	1	1	1	NA	1	1	1	NA	NA	NA
		Broadcast to Aircraft	3	2	2	2	2	2	NA	2	2	2	3	NA	NA
		Broadcast from Aircraft	NA	3	3	3	3	3	3	3	3	3	NA	NA	3
		Ground to Air Data	3	3	3	3	3	3	NA	3	3	NA	NA	NA	NA
		Air to Ground Data	3	3	3	3	3	3	NA	3	3	NA	NA	NA	NA
		Air to Air Data	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Video Exchange	2	2	2	2	2	2	NA	2	2	NA	NA	NA	NA
		Command and Control	NA	NA	NA	NA	3	NA	NA	NA	NA	NA	NA	NA	3

Total Communication System Performance Levels (Cont)

Confidence

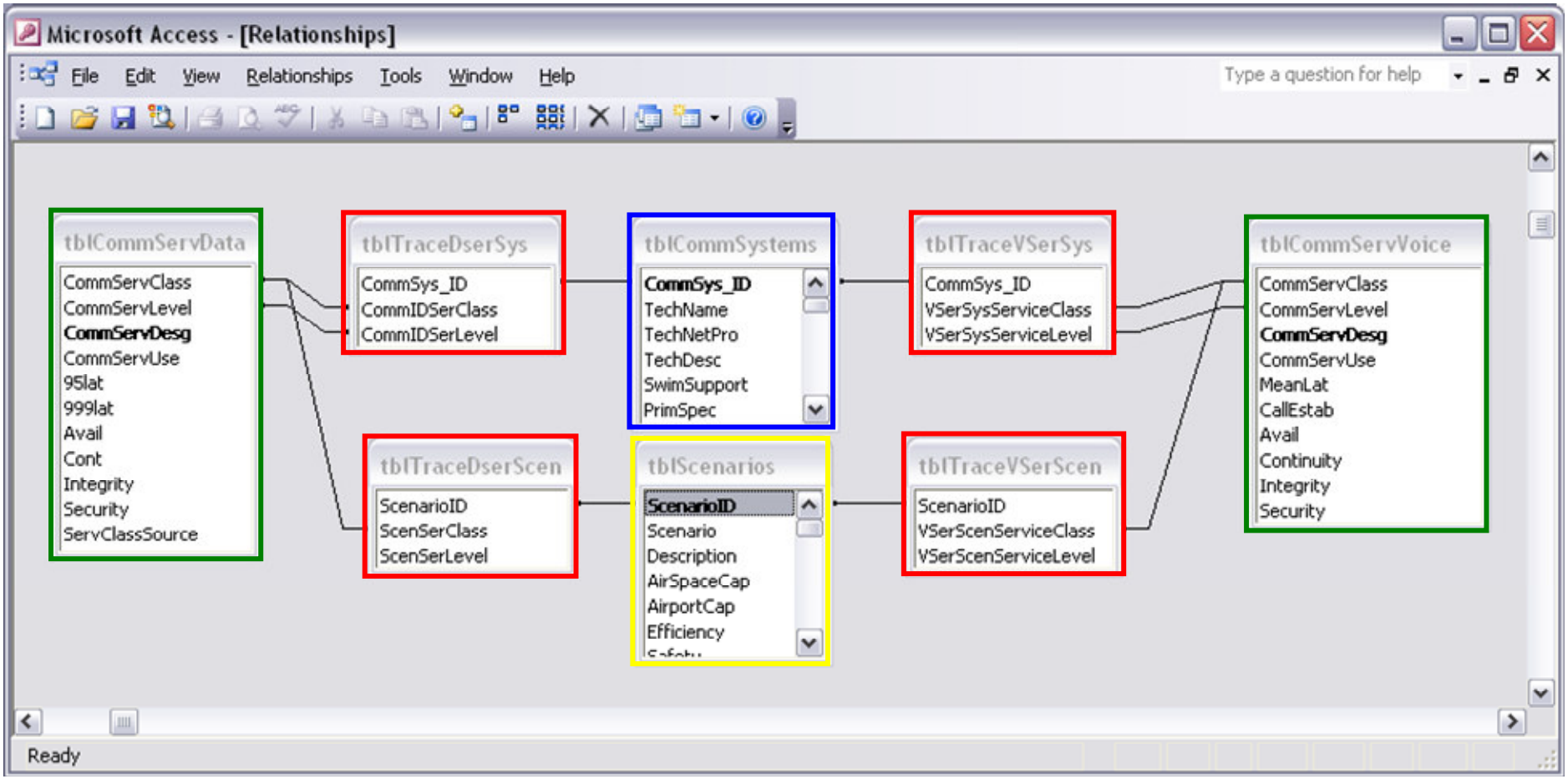
- High
- Medium
- Low

Service Levels

- NA — Not Available
- 1 — Most Stringent
- To
- 4 — Least Stringent

		Communication Service Class	Airspace Domains							Aircraft Classes					
			Gate	Surface	Terminal	En Route	Remote	Oceanic	Polar	Transport	Cargo	Business Jet	GA	Military	UAV/ROA
2010-2020	Voice	Party Line Voice	1	1	1	1	3	3	NA	1	1	1	1	1	2
		Selective Addressed Voice	1	1	1	1	2	2	3	1	1	1	NA	1	NA
		Broadcast Voice	1	1	1	1	1	1	NA	1	1	1	1	1	1
	Data	Data Messaging	1	1	1	1	1	1	3	1	1	1	NA	1	NA
		Trajectory Exchange	1	1	1	1	1	1	NA	1	1	1	NA	1	1
		Broadcast to Aircraft	3	2	2	2	2	2	NA	2	2	2	3	NA	NA
		Broadcast from Aircraft	NA	1	1	2	2	2	2	1	1	1	3	NA	2
		Ground to Air Data	2	2	2	2	2	2	NA	2	2	2	NA	NA	NA
		Air to Ground Data	2	2	2	2	2	2	NA	2	2	2	NA	NA	NA
		Air to Air Data	NA	NA	2	2	3	3	3	2	2	2	NA	NA	NA
		Video Exchange	2	2	2	1	1	1	NA	2	2	NA	NA	NA	1
		Command and Control	NA	NA	NA	2	3	3	NA	NA	NA	NA	NA	NA	2
2020-2030	Voice	Party Line Voice	1	1	1	1	1	1	NA	1	1	1	1	1	1
		Selective Addressed Voice	1	1	1	1	2	2	2	1	1	1	1	1	NA
		Broadcast Voice	1	1	1	1	1	1	NA	1	1	1	1	1	1
	Data	Data Messaging	1	1	1	1	1	1	2	1	1	1	1	1	NA
		Trajectory Exchange	2	2	1	1	1	1	2	1	1	1	1	1	1
		Broadcast to Aircraft	3	1	1	1	1	1	3	1	1	1	1	1	NA
		Broadcast from Aircraft	NA	1	1	2	2	2	2	1	1	1	1	1	1
		Ground to Air Data	2	1	1	1	1	1	NA	1	1	1	1	1	NA
		Air to Ground Data	2	1	1	1	1	1	NA	1	1	1	1	1	NA
		Air to Air Data	NA	NA	1	1	1	1	1	1	1	1	1	1	NA
		Video Exchange	2	1	1	1	1	1	NA	2	2	NA	NA	NA	1
		Command and Control	NA	1	1	1	3	3	3	NA	NA	NA	NA	NA	1

MCNA Access Database Relationship Diagram



Example: Access Database Output

Scenario #1 (Deploy FIS-B Nationally)

Service Class	Level	Comm. ID	Technology	Level	Total Cost	Year	Protocol	SWIM Support	Domain Holes	Gate	Surface	Terminal	Enroute	Remote	Oceanic	Polar	AirClass Holes	Transport	Cargo	Business Jet	GA	Military	UAV
Broadcast to Aircraft	3	23	1090-ES	1	1	2005	Layer-2	1	0	X	X	X	X	NA	NA	NA	1	X	X	X	O	X	NA
Broadcast to Aircraft	3	7	VDLm2	2	2	2005	NA	2	0	X	X	X	X	NA	NA	NA	0	X	X	X	X	X	NA
Broadcast to Aircraft	3	31	IEEE 802.11	3	4	2010	IP	3	3	X	O	O	O	NA	NA	NA	1	X	X	X	X	O	NA
Broadcast to Aircraft	3	24	UAT	1	5	2010	Layer-2	2	1	O	X	X	X	NA	NA	NA	3	O	O	X	X	O	NA
Broadcast to Aircraft	3	18	SDARS	2	5	2015	IP	2	0	X	X	X	X	NA	NA	NA	0	X	X	X	X	X	NA
Broadcast to Aircraft	3	17	Swift Broadband	2	5	2010	IP	3	0	X	X	X	X	NA	NA	NA	0	X	X	X	X	X	NA
Broadcast to Aircraft	3	20	Iridium	3	5	2005	Layer-2	1	0	X	X	X	X	NA	NA	NA	0	X	X	X	X	X	NA
Broadcast to Aircraft	3	33	IEEE 802.16	1	6	2020	IP	3	2	X	X	O	O	NA	NA	NA	1	X	X	X	X	O	NA
[illegible]	[illegible]	[illegible]	TETRA I/II	1	6	2025	IP	2	2	X	X	O	O	NA	NA	NA	0	X	X	X	X	X	NA
[illegible]	[illegible]	[illegible]	IEEE 802.20	2	6	2025	IP	3	2	X	X	O	O	NA	NA	NA	1	X	X	X	X	O	NA
[illegible]	[illegible]	[illegible]	VDLm2	3	6	2010	IP	2	0	X	X	X	X	NA	NA	NA	2	X	X	X	O	O	NA
[illegible]	[illegible]	[illegible]	3G	1	7	2020	IP	3	0	X	X	X	X	NA	NA	NA	1	X	X	X	X	O	NA
[illegible]	[illegible]	[illegible]	Airport Data Link	1	7	2025	NA	3	2	X	X	O	O	NA	NA	NA	1	X	X	X	X	O	NA
[illegible]	[illegible]	[illegible]	Swift 64	3	7	2005	IP	1	0	X	X	X	X	NA	NA	NA	1	X	X	X	O	X	NA
[illegible]	[illegible]	[illegible]	SDLS	2	8	2015	NA	2	0	X	X	X	X	NA	NA	NA	0	X	X	X	X	X	NA
[illegible]	[illegible]	[illegible]	Connexion by Boeing	3	9	2005	IP	3	2	O	O	X	X	NA	NA	NA	1	X	X	X	O	X	NA
[illegible]	[illegible]	[illegible]	B-VHF	1	9	2025	IP	3	0	X	X	X	X	NA	NA	NA	2	X	X	X	O	O	NA
Broadcast to Aircraft	3	25	P-34	1	10	2025	IP	3	0	X	X	X	X	NA	NA	NA	2	X	X	X	O	O	NA

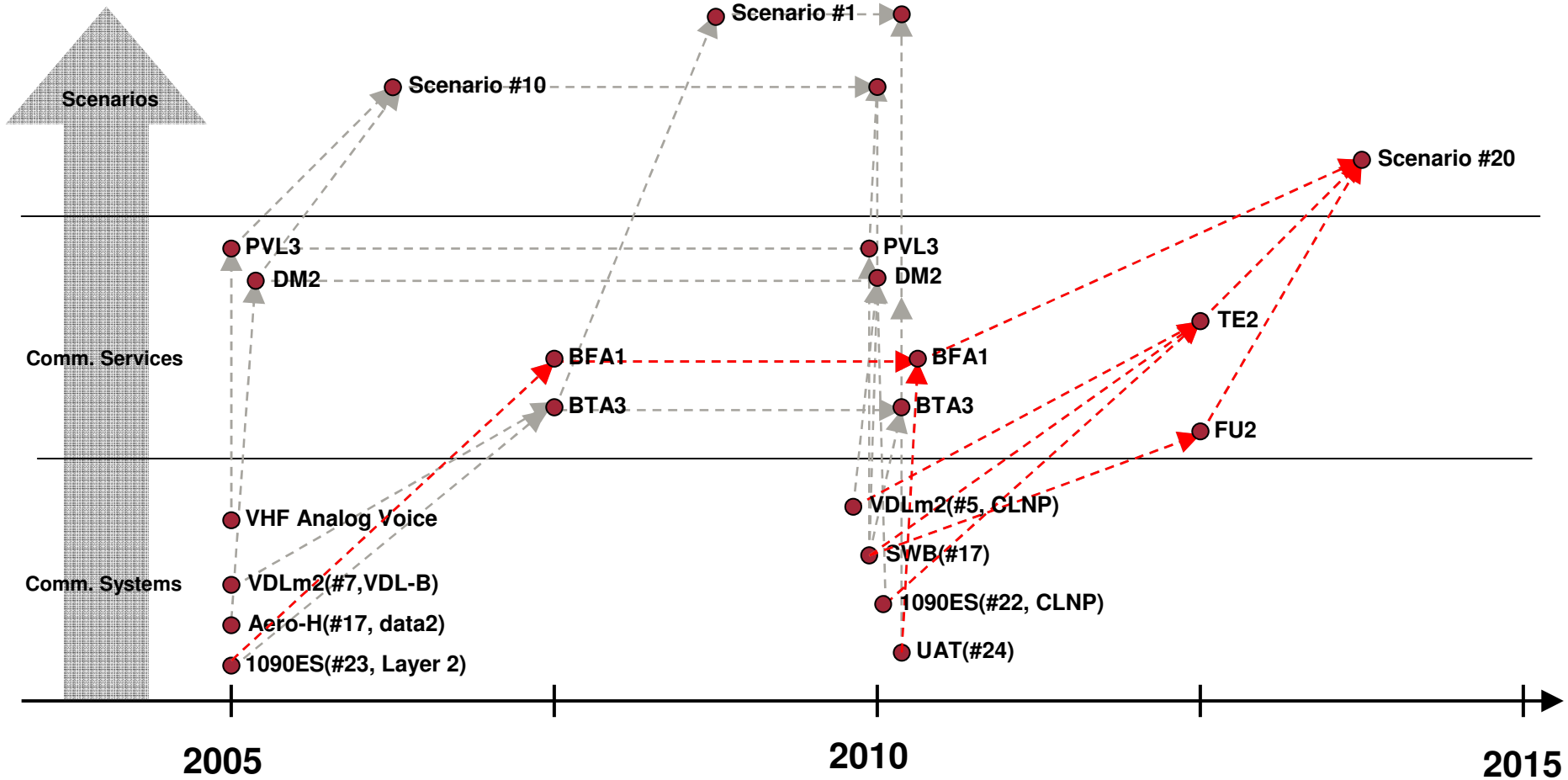
Cov. Legend

X = Covered

O = Hole

NA = Not Applic.

Representative Transition Paths
(AIM & Flight Objects)



Scenario #1 (Deploy FIS-B Nationally)

Scenario #10 (Datalink to reduce routine workload)

Scenario #20 (Optimize Runway Assignments)

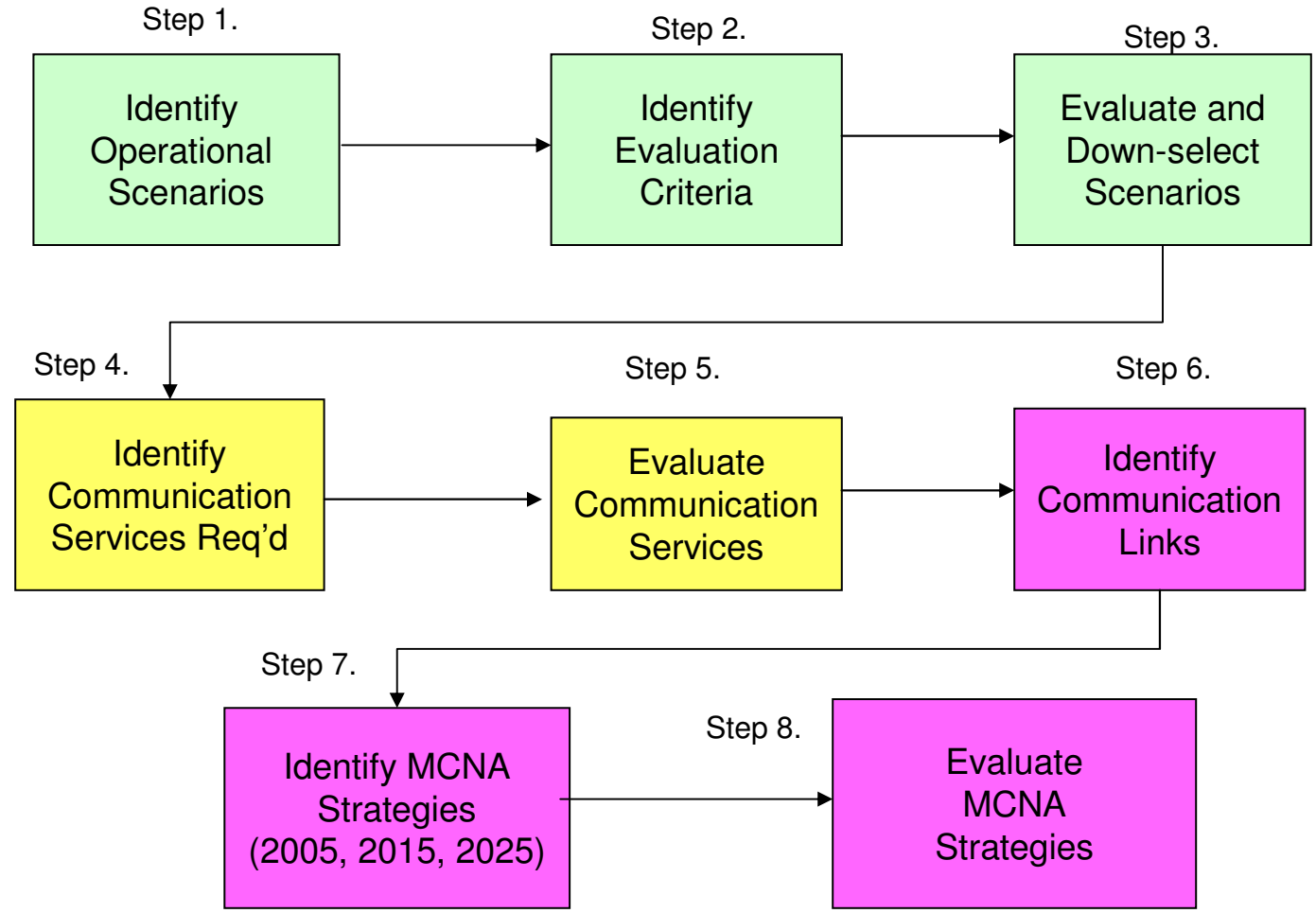
BOEING

Boeing Technology
Phantom Works

Investment Analysis

Steve Glickman & Karl Griep
MCNA Final Briefing
15 August 2005

MCNA Investment Strategy Analysis



Scenario and Evaluation Criteria

36 Scenarios Identified as representative set

- Sources:
  - NAS 5.0 Operational Improvements (OI)
  - AATT RTO-24,
  - MACONDO,
  - SWIM Investment Analysis (Information Migrations & SWIM enabled applications)
  - MCNA team brainstorming

Scenarios were evaluated on benefit and risk:

- Benefit
  - Safety
  - Airspace Capacity
  - Airport Capacity
  - Flight Path Efficiency
  - Security

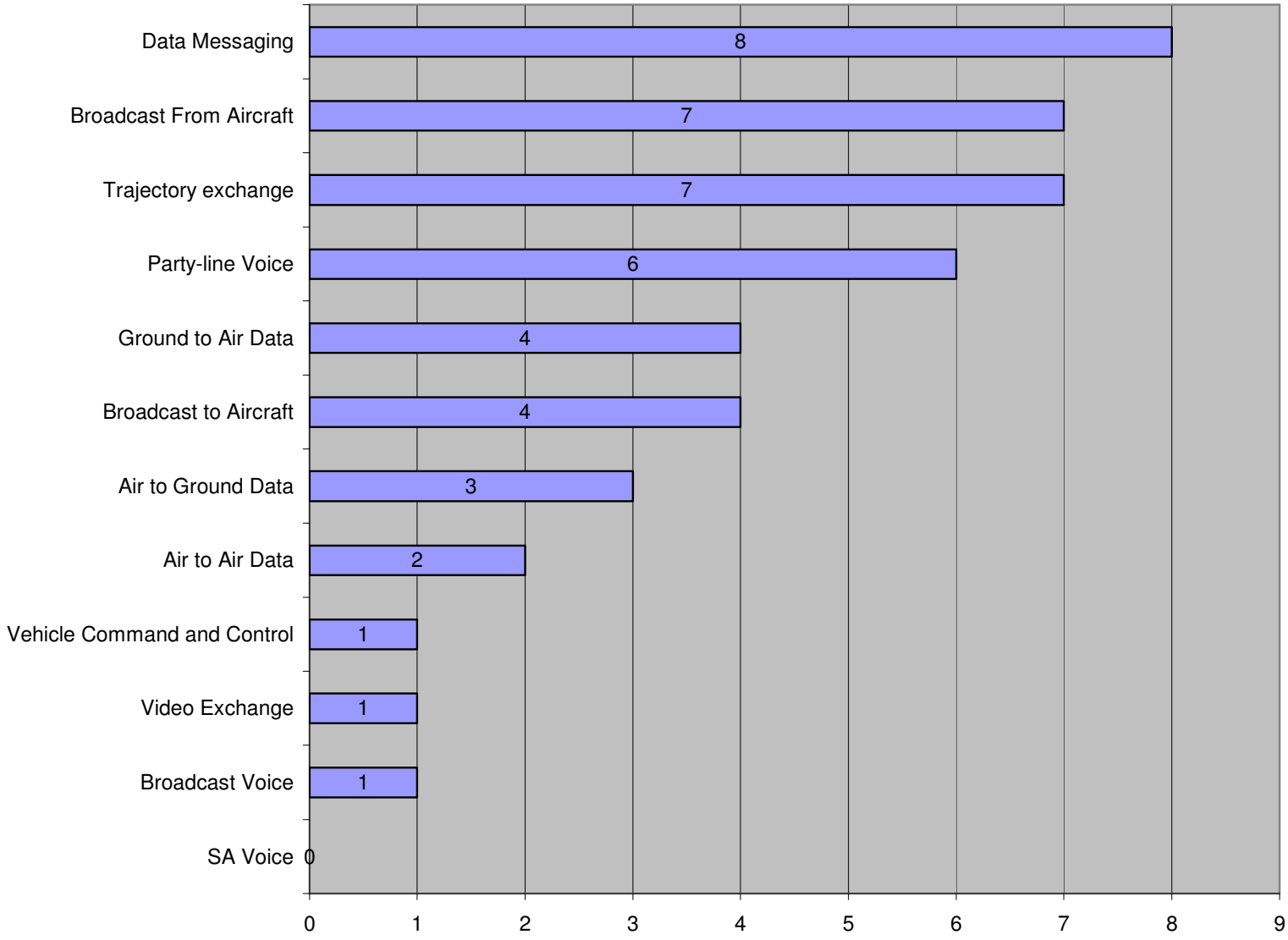
- Risk
  - Non-technical: Political and Operational Acceptance
  - Technical: Workload or Automation System Complexity
  - Ground Implementation: Relative cost of ground implementation
  - Airline Implementation: Relative cost or airline implementation

Additional High Risk Scenarios Added

- ROA Control
- UAV Control
- Dynamic Resectorization
- Improved Surface Separation Assurance
- Shared Responsibility for Horizontal Separation

High-risk potentially high value scenarios were identified for inclusion in strategy analysis

Communications Service Assessment



MCNA Strategy Roadmap

	Air-to-Ground Voice (CONUS)	Air-to-Ground Data (CONUS)	Satellite Comm (Polar, Remote, Oceanic)	Air-to-Air Comm	Airport Comm	Networking Protocols
2005	VHF Analog	POA VDL2	HF Voice HFDL Aero-H	1090- ES UAT	Limited Use	ACARS
2015	8.33 kHz Analog	VDL2 SWIFT Broadband	HF Voice Aero-H Swift-64 SWIFT Broadband SDARS	1090-ES UAT	IEEE 802.11 IEEE 802.16	Multiple Protocols
2025	8.33 kHz Analog P25	P34 SWIFT Broadband	SWIFT Broadband SDARS	1090-ES UAT	IEEE 802.16	IP

Strategy Assessment

Delivers Scenario

Maybe delivers scenario

Won't deliver scenario

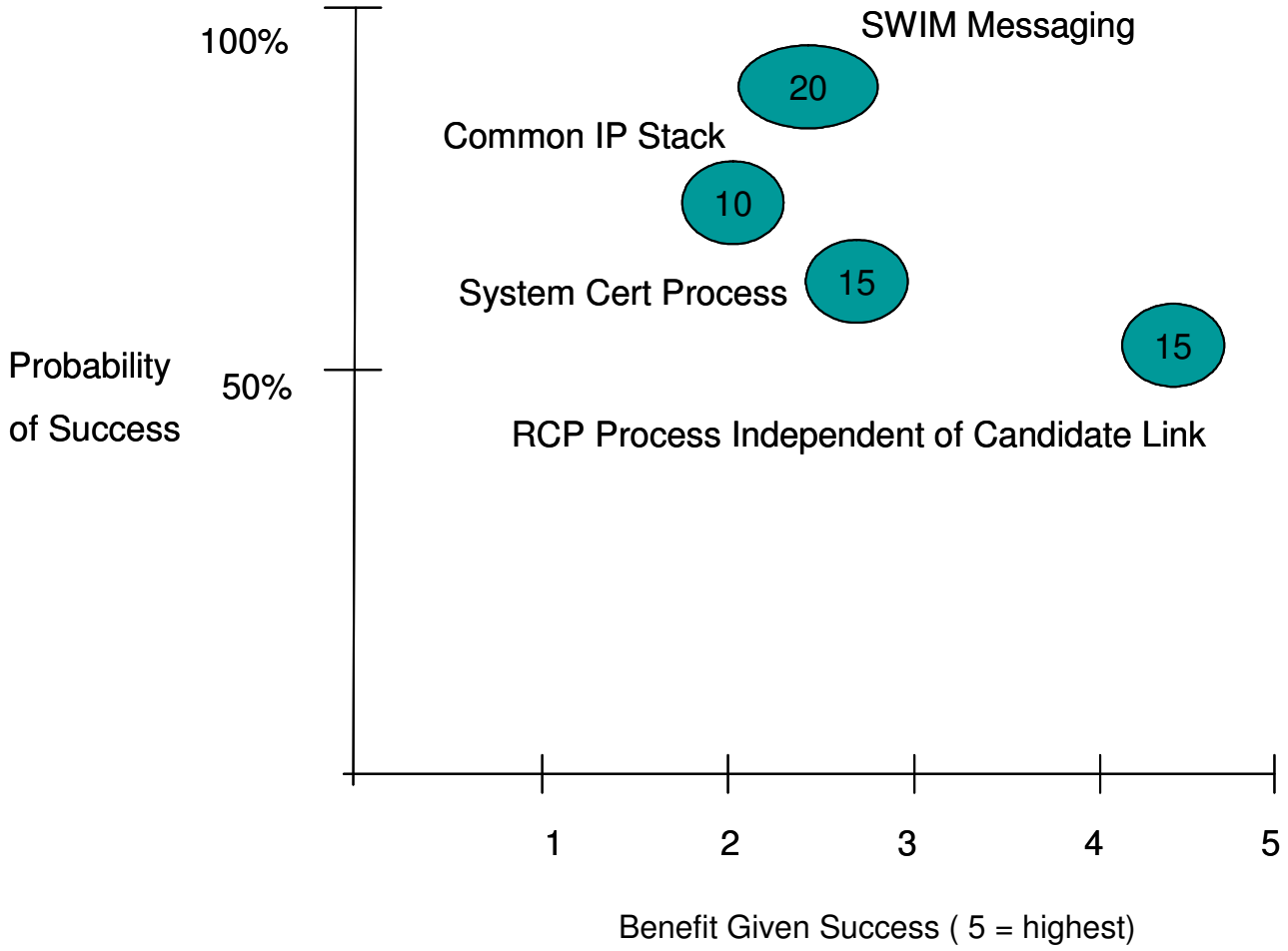
	Scenario	Communication Services															
		Party-line Voice	SA Voice	Broadcast Voice	Data Messaging	Trijaecotry exchange	Broadcast to Aircraft	Broadcast From Aircraft	Ground to Air Data	Air to Ground Data	Air to Air Data	Video Exchange	Vehicle Command and Control	2005	TSD 2015	MCNA 2015	MCNA 2025
1	Deploy FIS-B Nationally						3										
5	Autonomous Hazard Weather Alert Notification			2	2		2		2								
10	Datalink to reduce routine workload	2			2												
15	Enhanced Emergency Alerting							1									
20	Optimize Runway Assignments					2		1	2								
25	Controller awareness of ACAS resolutions				1												
29	Aircraft push of security video and aircraft performance during emergency							2		2		2					
32	Push of Security advisories to aircraft				2												
16	Enhance Flight Data Management					2											
17	Interactive Flight Planning From Anywhere					2											
18	Oceanic Separatoin to RNP-4	4			2	2											
22	Flow Planning with distributed Schedule Recovery and Post Departure Rerouting					2											
30	ROA Control	2			2					1	1		1				
31	UAV Control					1	2	1	2	2							
38	Dynamic Resectorization	2			1	2	1	1									
13	Improved Surface Separation Assurance	3			1			1	2								
9	Shared Responsibility for Horizontal Separation	3						1			1						

MCNA Enabling Technology Assessment

- Identify enabling technologies for MCNA
- Assess:
  - Objective of the Research
  - Estimated Cost of Research
  - Exit Criteria
  - Technical Showstoppers
  - Non-technical Showstoppers
  - Probability of success
  - Description of impact if we fail
  - Impact rating: MCNA Technical, Schedule and Cost Risk
- Evaluated cost/risk/return tradeoff using R&D Decision Analysis techniques[1]
- Still need to reconcile enabling technologies with Technology Gaps and Roadmap

1. The Smart Organization; Matheson and Matheson; Harvard Business School Press, 1997.

Enabling Technology Assessment



Conclusions

- **Data Messaging, Trajectory Exchange and Party-Line Voice are high-value services**
  - **Investment in links that enable these services will have the highest leverage**
- **A 2015 MCNA strategy has been identified that can:**
  - **Clearly deliver 15 of 17 high value scenarios.**
  - **May be able to deliver the two remaining scenarios (ROA Control and Shared Responsibility for Horizontal Integration)**
  - **Is superior to the FAA TSD Strategy by leveraging satellite technology**
- **RCP Process is a highest value research area. Research on Common IP Stack, System Certification Process and SWIM Messaging also show promise.**

Boeing Technology
Phantom Works

MCNA Technology Roadmap Development

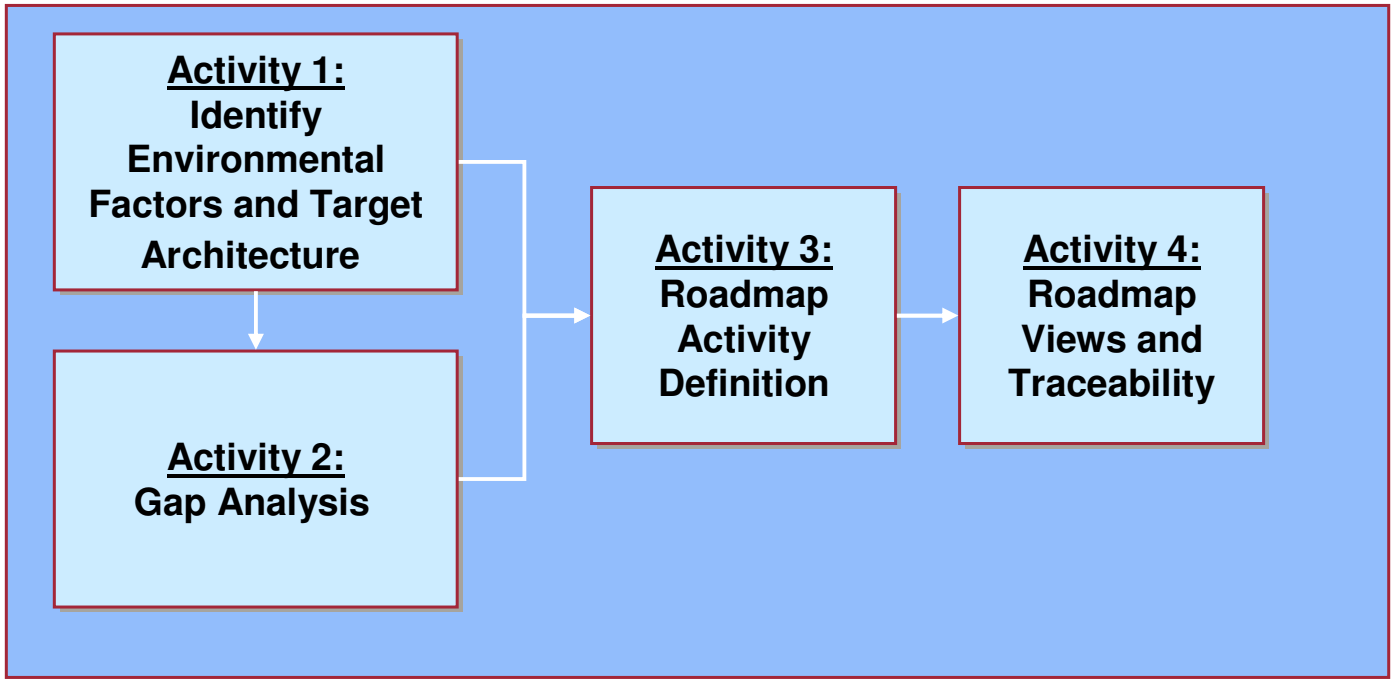
ITT Industries
MCNA Final Briefing
15 August 2005

Objectives

- Identify gaps and characteristics or limitations that need to be addressed to implement the integrated (mobile and terrestrial) communication network architecture
- Draft a 10-year roadmap for the “2015” target system architecture

Gap Analysis and Roadmap Development Work Flow Diagram

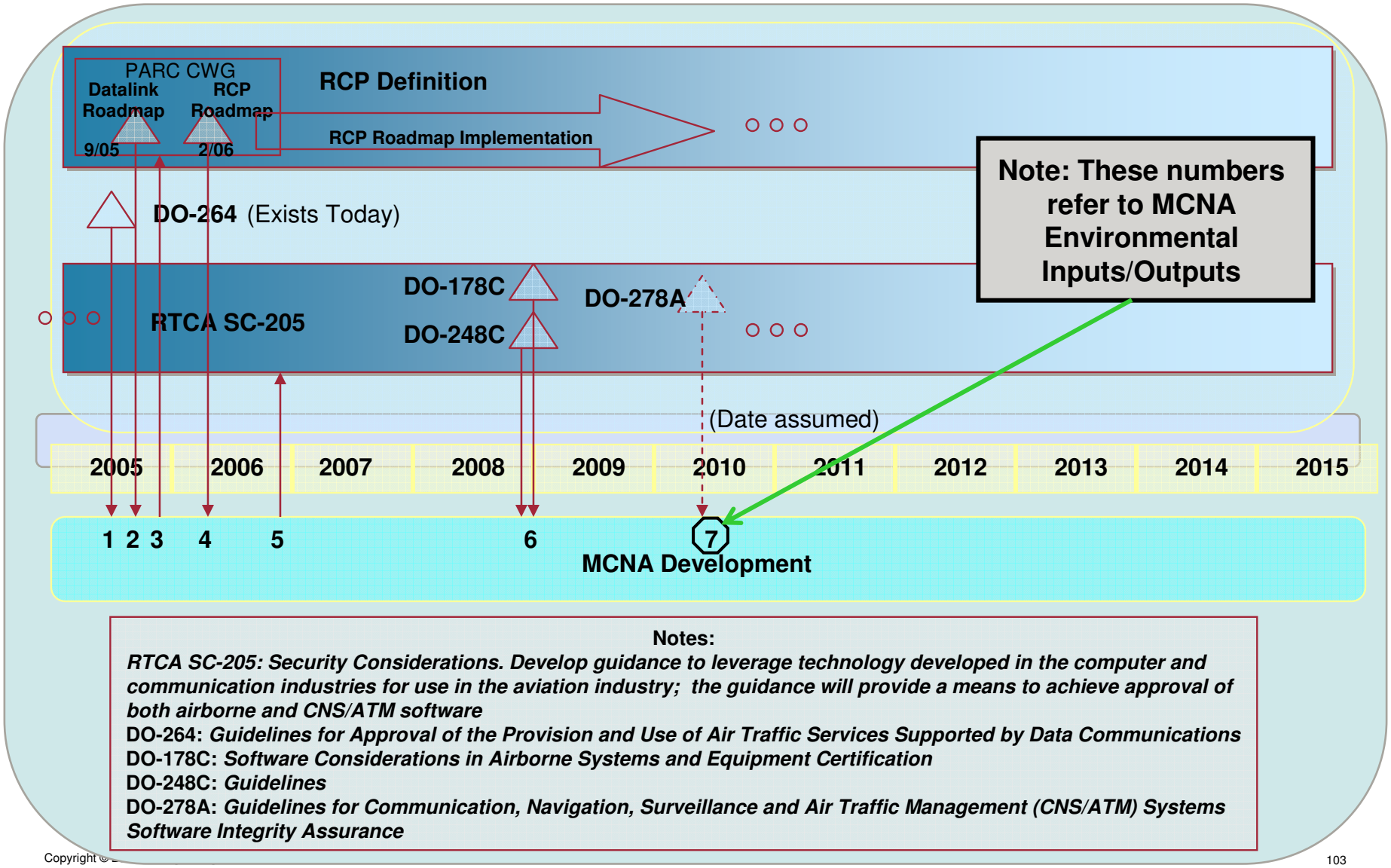
- **This task consisted of four principal activities closely tied to other MCNA development activities**



Activity 1: Environmental Elements and 2015 Concept Formulation

- This activity addressed the identification of environmental factors applicable to MCNA development and included formulation of a target 2015 MCNA concept
  - These factors were addressed in five broad categories
    - Process Development
    - Link Technologies
    - Network Technologies
    - Security
    - System Integration
  - The target 2015 MCNA concept was developed based on material developed during MCNA functional analysis and architecture and transition planning development

Activity 1: Environmental Element – Improved Process Development



Notes:

***RTCA SC-205:** Security Considerations. Develop guidance to leverage technology developed in the computer and communication industries for use in the aviation industry; the guidance will provide a means to achieve approval of both airborne and CNS/ATM software*

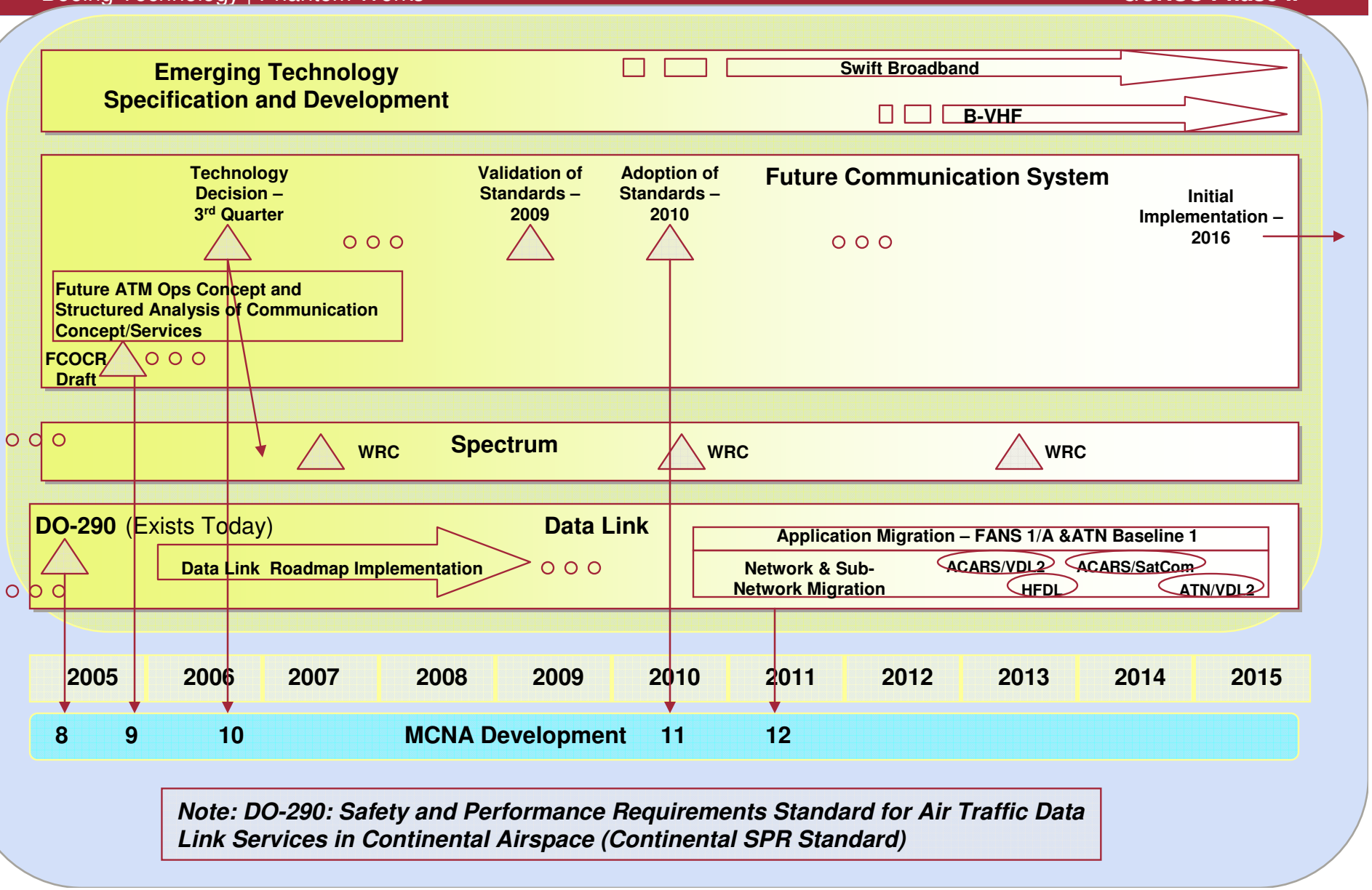
DO-264: ***Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications***

DO-178C: ***Software Considerations in Airborne Systems and Equipment Certification***

DO-248C: ***Guidelines***

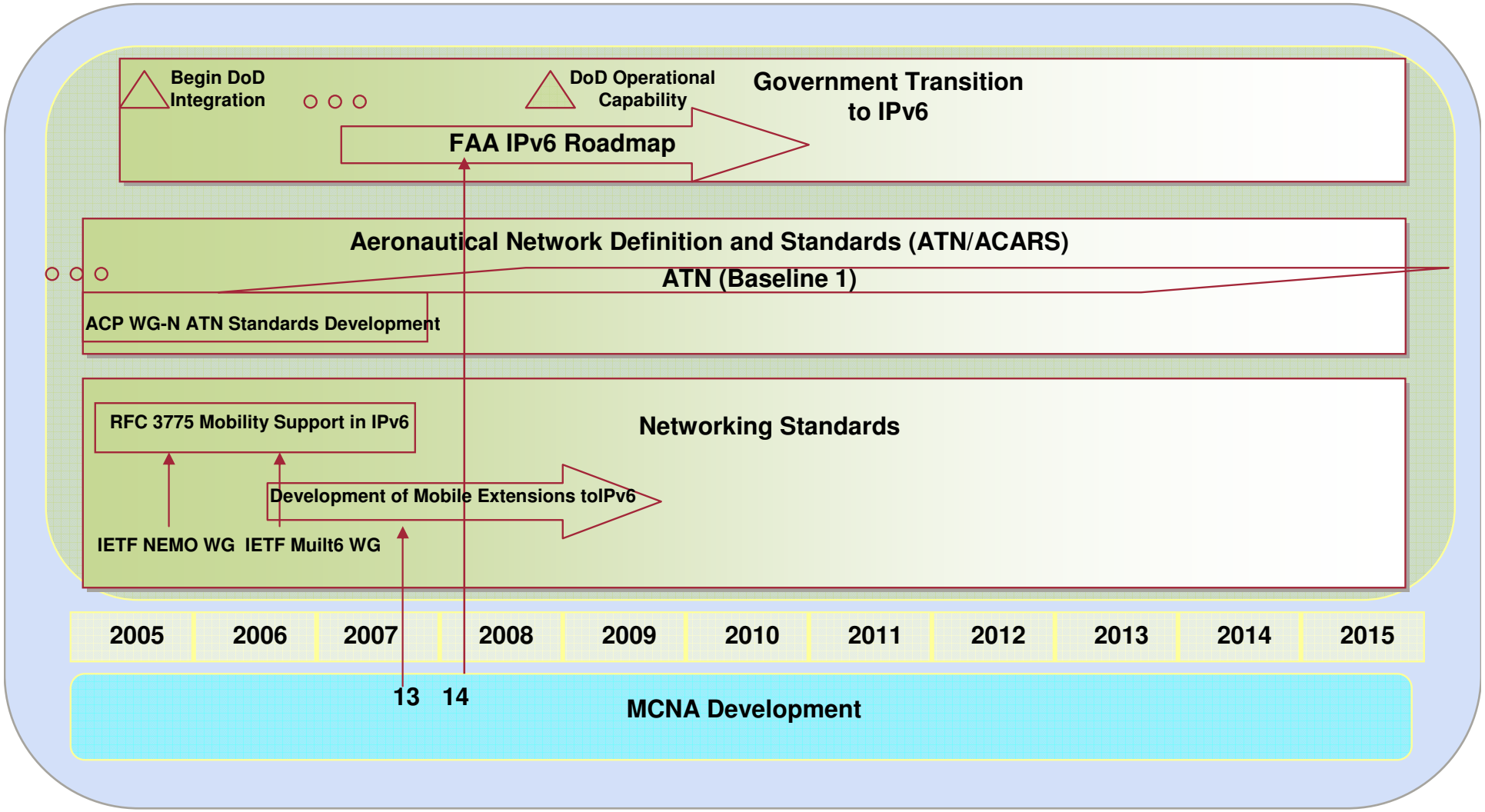
DO-278A: ***Guidelines for Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance***

Activity 1: Environmental Element – Link Technologies

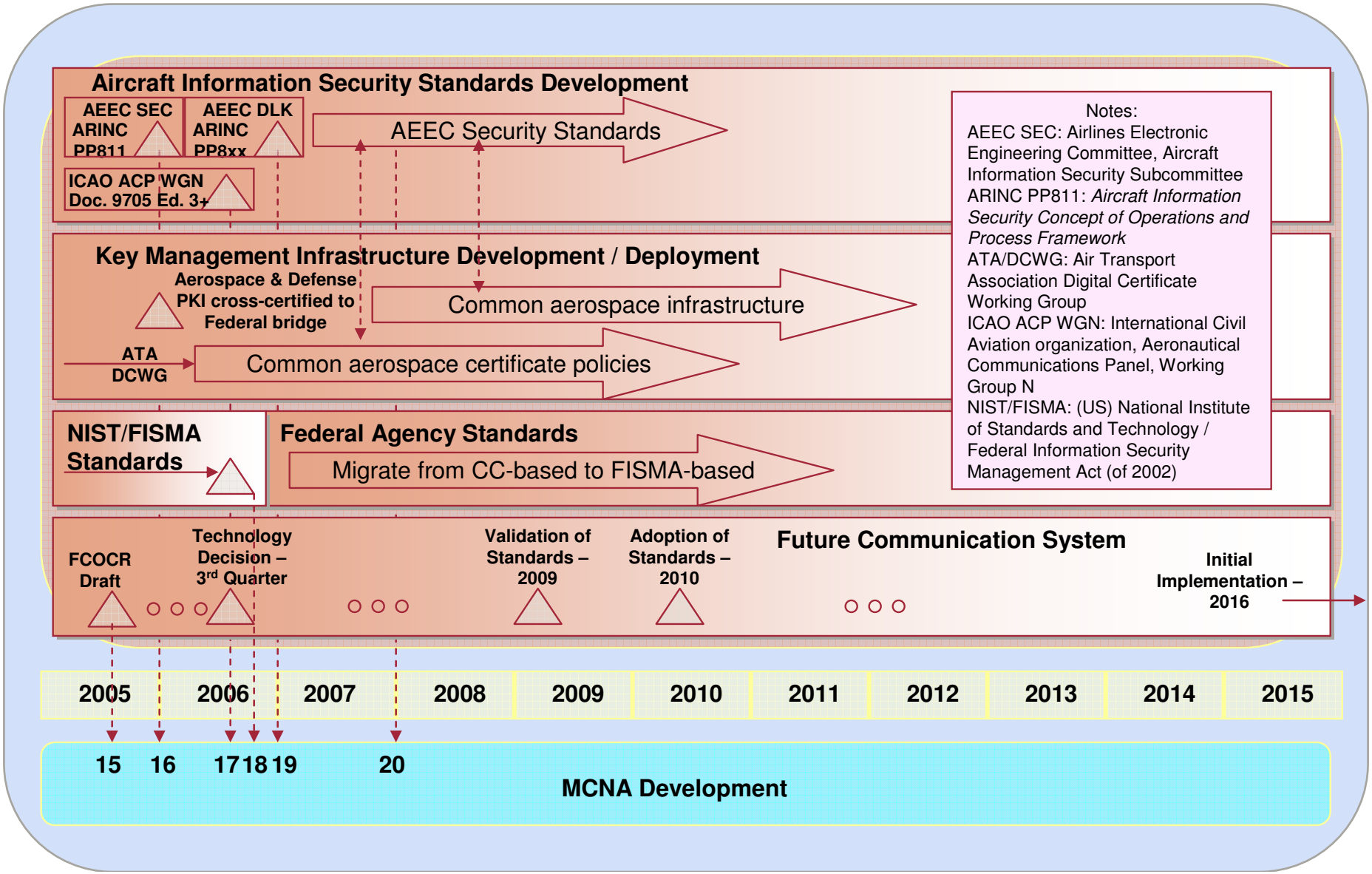


Note: DO-290: Safety and Performance Requirements Standard for Air Traffic Data Link Services in Continental Airspace (Continental SPR Standard)

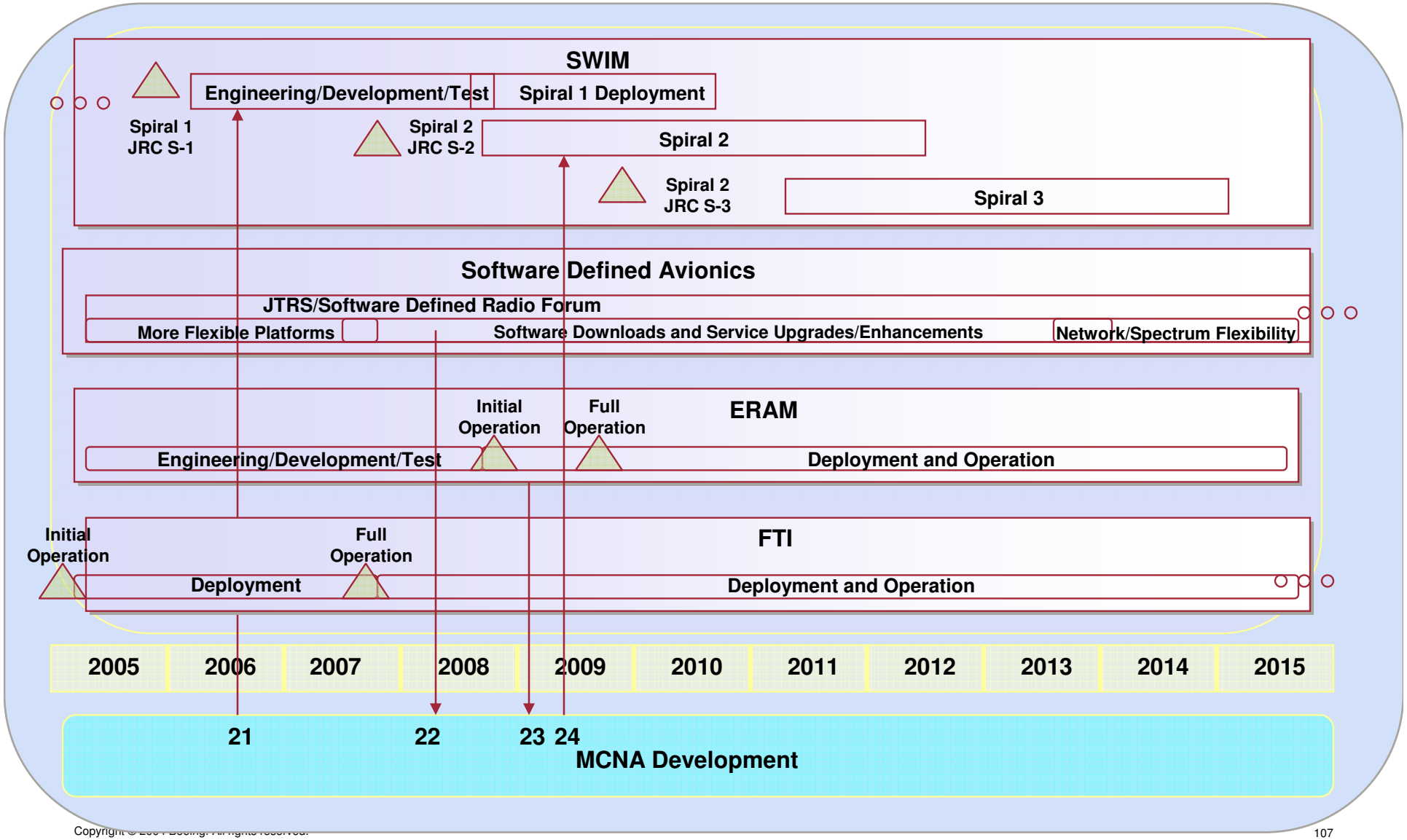
Activity 1: Environmental Element – Network Technologies



Activity 1: Environmental Element – Security



Activity 1: Environmental Element – System Integration



Excerpt from Input/Output Summary Table

	Item	Category	Input/ Output	Time	Applicability
1	DO-264 Guidelines for approval of ATS Supported by data link	Improved Process Development	Input	Current	Support development of certification process for use of commercial software and systems in MCNA architecture
2	PARC CWG Data Link Roadmap	Improved Process Development	Input	Fall 2005	Lays out road to FAA datalinks that can be considered when validating the MCNA architecture and requirements as well as transition plan
3	Inputs to PARC CWG RCP Definition Process	Improved Process Development	Output	Late 2005	Bring MCNA outputs and RCP issues to the CWG for consideration; participate in CWG as appropriate
4	Inputs to SC-205 to request expanded scope and support development efforts	Improved Process Development	Output	2006	Supports MCNA inputs to defining a process for certifying commercial systems for ATC and AOC ops
5	PARC CWG RCP Roadmap	Improved Process Development	Input	Early 2006	Support refinement of MCNA architecture and transition plans
6	Updated documents DO-178C and DO-248C	Improved Process Development	Input	Late 2008, Early 2009	Supports MCNA inputs to defining a process for certifying commercial systems for ATC and AOC ops

Activity 1: Target 2015 MCNA Concepts

- The roadmap identifies specific activities to be accomplished over the next ten years to achieve a target 2015 MCNA capability; therefore, knowledge of this vision is an important aspect of roadmap development
  - As the MCNA development effort is in its infancy, there is not a full and detailed definition of the 2015 target architecture
    - Instead, information gathered and created during the MCNA tasks documented in this report have begun to outline the envisioned capability for the 2015 timeframe
  - Current target architecture concepts have been inferred from material described in or derived from the MCNA Functional Analysis report and the MCNA Transition Plan report

Activity 1: Target 2015 MCNA Concepts (cont'd)

- Based on the MCNA transition analysis, it is anticipated that existing (and potentially some new) communication capabilities will be present in the 2015 time frame to support the following mobile user communication capabilities:
  - Voice:
    - PL Voice (Service Level (SL) 1/3/4)
    - Selective Addressed Voice (SL 2)
    - Broadcast Voice (SL 1)
  - Data:
    - Messaging (SL 1/2/3)
    - Trajectory Exchange (SL 2)
    - Broadcast to A/C: (SL 2/3)
    - Broadcast from A/C (SL 2/3)
    - Ground to Air Data (SL 3)
    - Air to Ground Data (SL 3)
    - Video Exchange (SL 2)
    - C^2 (SL3)

In this list, the designation of service level has been used to describe the level of capability (or service class) within each communication service category

- **The levels generally range from 1 to 3 or 1 to 4, with 1 indicating the most stringent performance attributes and the higher numbers the more basic service qualities**
- **The activities in the MCNA roadmap should include activities that support the realization of these service classes within the NAS**

Activity 1: Target 2015 MCNA Concepts (cont'd)

- **Another view of the target architecture was created by reviewing the MCNA functions (from the functional analysis) and determining the desired/required level of capability per function by 2015**
  - **The capability level is specified in one of four ways:**
    - **Full: full deployment of the functionality throughout the NAS**
    - **Partial: partial deployment of the functionality within MCNA**
    - **Trial: functionality exists, but only for trial purposes in selected areas**
    - **None: functionality does not exist in the 2015 MCNA architecture**

Activity 1: Target 2015 MCNA Concepts (cont'd)

Excerpt from Target Functionality Table

Level 1 Function	Level 2 Function	Level 3 Function	Capability in 2015 Target Architecture	Comments
Provide Data Transport	Manage Connections And Sessions	Authenticate User	Partial	These could be introduced by either secure ACARS (if ever applied) ATN version 2 or as part of new IP-based services.
		Authorize Access	Partial	
		Establish Connection/Session	Full	Generic to any datalink subnetwork (datalink capability exists in target architecture)
		Maintain Connection/Session	Full	Generic to any datalink subnetwork (datalink capability exists in target architecture)
		Terminate Connection/Session	Full	Generic to any datalink subnetwork (datalink capability exists in target architecture)
	Manage Routing Policy And Mobility	Allocate Flows to Subnetworks	Trial	Specific to applicable applications and available subnetworks (min functionality)
		Move flows between subnetworks	Trial	Gateway functionality implemented to provide this capability
		Create a subnetwork connection	Full	Generic to any datalink subnetwork (datalink capability exists in target architecture)
		Terminate subnetwork connection	Full	Generic to any datalink subnetwork (datalink capability exists in target architecture)

Activity 2: Gap Analysis

- Identification of requirements, technology, certification, and/or cultural gaps or shortcomings specific to the implementation of the MCNA architecture
  - During the development of MCNA requirements, architecture concepts (both avionics and ground), and transition plans, a range of shortcomings were identified and documented
  - Recommendations to address 26 identified gaps were also formulated

MCNA Shortcomings

	Shortcoming	Category
1	RCP does not clearly provide provisions to meet a service using multiple systems	Requirements
2	RCP linearly divides expiration time allocations (in many cases, not necessarily all)	Requirements
3	RCP seems to lack sufficient operational analysis behind many quantified performance requirements	Requirements
4	Certain requirements such as multi-homing, policy based routing and priority/pre-emption are not clearly defined and universally applied	Requirements
5-6	IP lacks sufficient mobility and multihoming capabilities as defined by ATN	Technology
7	New IP-based communication links should be able to support multiple classes of communications to provide better justification to equip	Technology / Cultural
8	Lack of a mechanism to multicast messages to managed groups of users	Technology
9	Physical connection between A-G transceivers and sectors limits the ability to transition towards an agile NAS	Technology / Culture
10	Lack of masquerading prevention in voice services	Technology / Culture
11	Lack of masquerading in data services	Technology
12	Certification cost of commercial avionics is a significant barrier to the introduction of additional low cost avionics to also enhance ATS communications	Certification
13	During the near term, ACARS, ATN and IP links/networks will all coexist. Need a means to integrate these disparate networks to provide an integrated communication service offering.	Technology
14	Need means of supporting address mobility for IP while maintaining efficient routing	Technology
15	Traditional transport layer protocols (i.e. TCP) implements congestion control mechanisms that may not be efficient in a wireless environment	Technology

MCNA Shortcomings (cont'd)

	Shortcoming	Category
16	May need to convert application layer protocol data formats for transport over bandwidth constrained wireless links	Technology
17	Need Topology Control Mechanism for the ad hoc MCNA network	Technology
18	Need to determine MCNA routing protocols that coordinate efficiently with existing and planned link layer protocols and what routing protocols are offered by FTI, ATN, etc	Technology
19	Some MCNA applications may require multicast routing capabilities	Technology
20	Conclusion 1: There is currently no FAA acknowledged process in place by which a commercial system can be approved for the transmission of safety services, including both ATS and AOC services.	Certification
21	There is currently no FAA acknowledged process in place by which a commercial system can be approved for the transmission of safety services, including both ATS and AOC services.	Certification
22	There is no widely acknowledged paradigm for the use of commercial terrestrial telecommunications infrastructure for safety information, even though this use occurs every day.	Certification
23 - 25	There is currently no FAA acknowledged process in place by which avionics suitable for use with a commercial system can be approved for the transmission of safety services, safety services, including both ATS and AOC services. It is uncertain which organization within FAA would receive or approve such documentation as a basis for a TSO- or PMA-based approval. Including both ATS and AOC services.	Certification
26	Once the significant questions raised regarding system and avionics certification are resolved, the current aircraft certification process appears to be sufficient to support the approval for individual services. However, the current process may not be sufficient for anticipated future RCP applications.	Certification

Activity 3: Roadmap Activity Definition

- To address the defined target 2015 architecture and associated gaps, three developmental steps were defined
  - Phase I: System Engineering Product Refinement; Process/Technology Investigation and Definition; and Experimentation Planning
  - Phase II: Technology Experimentation/Validation; Initial SWIM Integration; and Service Partitioning/Network Integration Planning
  - Phase III: Technology demonstration; initial service partitioning/integrated network validation; and full SWIM integration

Activity 3: Roadmap Activity Definition - Phase I

- Phase I: System Engineering Product Refinement; Process/Technology Investigation and Definition; and Experimentation Planning
  - This phase supported two major activities:
    - On-going System Engineering Analysis and Process Development:
      - Refinement/validation of MCNA architecture/requirements
      - Refinement of gap analysis
      - Definition of certification processes and documentation to address the use of commercial software/systems in ATC and AOC applications
      - Support of definition of RCP through structured analysis of required communication functions/capabilities
    - Experimentation Planning and Technology Investigation
      - Development of plans for conducting experiments specific to the role of technology required for MCNA
      - Investigation and development of MCNA network security requirements and technologies
      - Extension of mobile networking protocols to the aeronautical environment

Activity 3: Roadmap Activity Definition– Phase II

- Phase II: Technology Experimentation/Validation; Initial SWIM Integration; and Service Partitioning/Network Integration Planning
  - This phase included:
    - Introduction of initial concepts of the future avionics architecture, including support for standardization of future software defined avionics
    - Definition and evaluation of service partitioning and network integration concepts (including simulation/emulation)
    - Validation of data link technologies for supporting required communication services classes
    - Technology experimentation
    - Initial SWIM Integration
    - Total system integration (all stakeholders) and global interoperability planning

Activity 3: Roadmap Activity Definition - Phase III

- Phase III: Technology demonstration; initial service partitioning/integrated network validation; and full SWIM integration
  - This phase included:
    - Continued technology experimentation and technology demonstration
    - Evaluation and validation of service partitioning and network integration architectures
    - Demonstration of the initial integrated network capability (for defined communication services and applications)
    - Full integration of MCNA into SWIM service infrastructure

Activity 3: Definition of Specific Roadmap Elements

- For each MCNA Development Phase, specific activities (or roadmap elements) were defined
  - These elements addressed the key items noted on previous slides for each development phase
  - Included elements that address gaps uncovered during gap analysis
  - Incorporated elements that accommodate recommended SED activities
- Some roadmap activities are relatively straight-forward, while other activities are broader in scope and should be refined and detailed during follow-on systems engineering activities supporting MCNA development

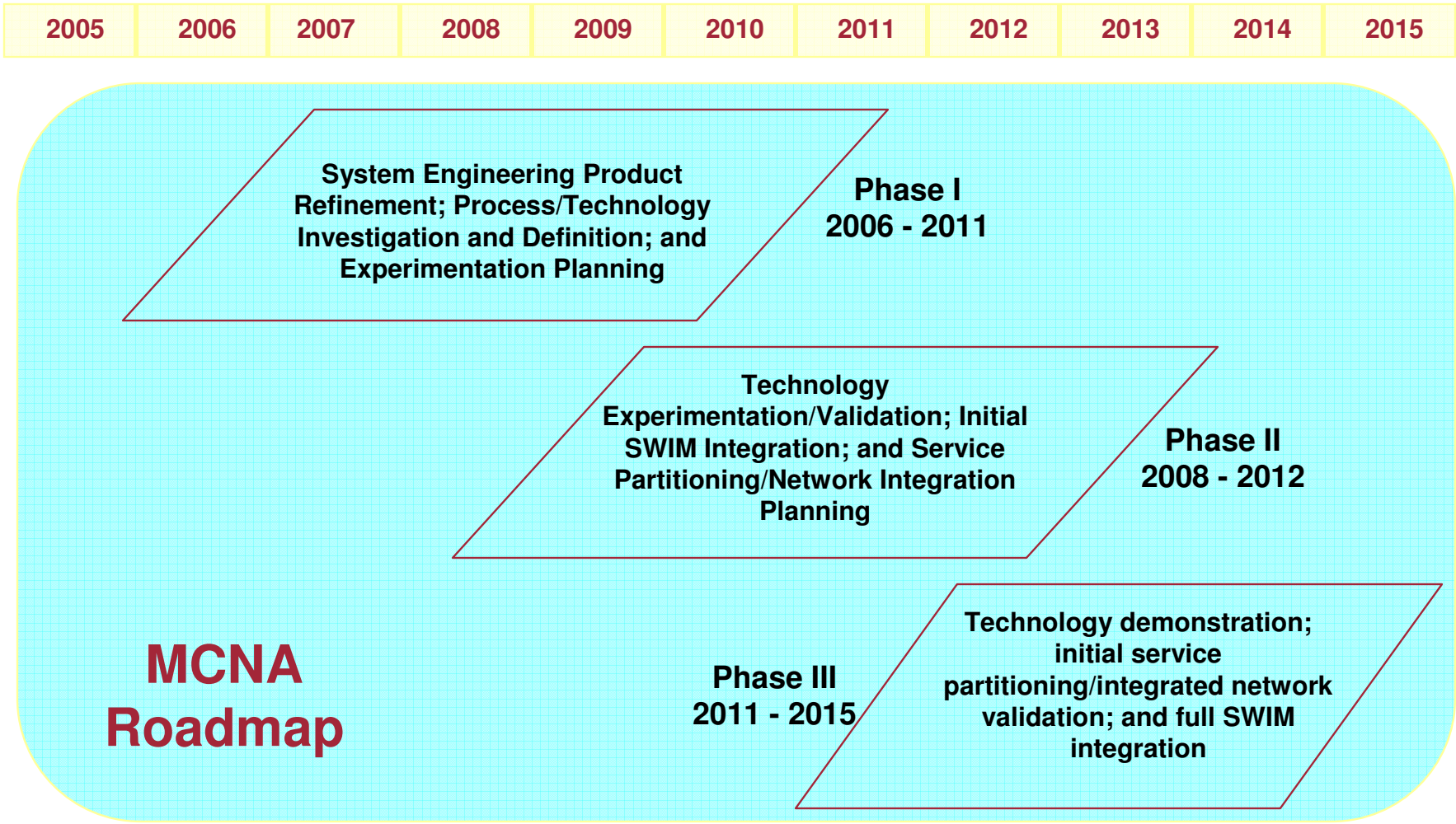
Activity 3: Definition of Specific Roadmap Elements

ID	MCNA Roadmap Element	Developmental Step
1	Refinement of Architecture, Requirements, Transition Plan	Phase I
2	Certification Process Definition/Standardization Support: Develop process for submission and review of relevant data supporting the certification of Commercial Systems/Software for AOC and ATS applications	Phase I
3	Certification Documentation Definition Support: Define required documentation for the defined process of certifying commercial systems for AOC and ATS applications	Phase I
4	Structured Analysis of Communication Services and RCP: Participate in RCP definition of end-to-end performance (including support for safety analysis)	Phase I
5	IPv6 Mobility Standards & IP-based Datalink Development (includes participation in Mobile IP Standards Organizations to define an aeronautical IPv6 with appropriate security, mobility and peer-to-peer support)	Phase I
6	MCNA Network Security Analysis	Phase I
7	Experimentation Planning: Defining and planning specific experimental tasks supporting MCNA technologies and architecture concepts	Phase I
8	Future Avionics Technologies (e.g. SDA) and Architecture Evaluation	Phase II
9	Security Impact Analysis and Requirements Development	Phase II
10	SWIM Testbed Integration (initial mobile user capability for SWIM Spiral 1)	Phase II
11	Evaluation of Service Partitioning/Network Integration Technologies and Concepts	Phase II
12	Conduct Technology Experimentation	Phase II
13	Service Partitioning and Network Experimentation	Phase III
14	MCNA Technology Demonstration	Phase III
15	Additional SWIM Capability to Mobile User and Native Network Centric Operation Engineering	Phase III
16	Integrated Network Demonstration	Phase III

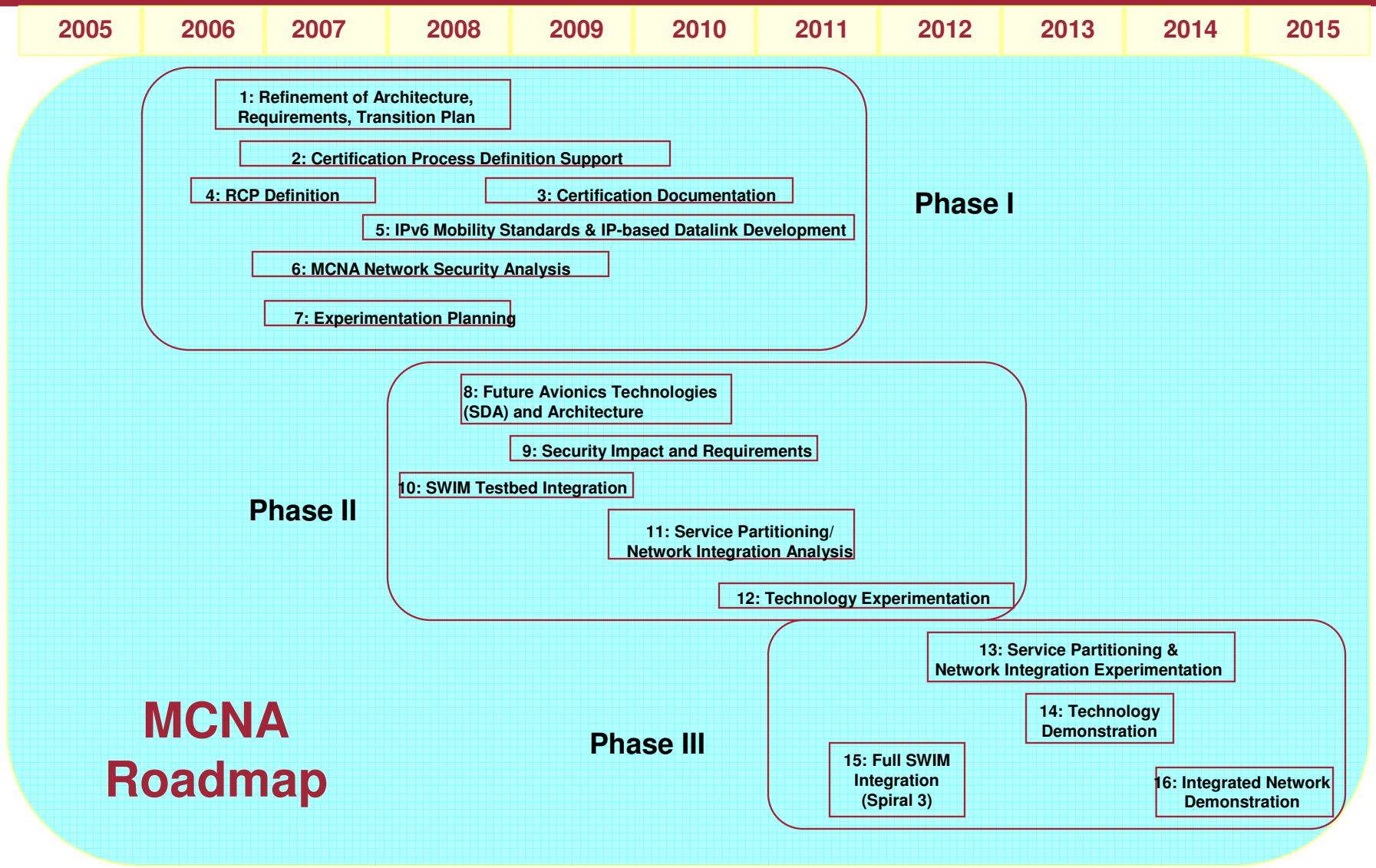
Activity 4: MCNA Roadmap Development

- This activity includes:
  - Development of the actual MCNA roadmaps (adding the time context to the roadmap elements)
    - A high-level overview of the three planned phases of MCNA development over the next ten years
    - A more detailed layout of recommended activities to continue MCNA development and implementation over the next ten years
      - Accommodates inter-relationships among roadmap activities and relationships to environmental activities
  - Roadmap traceability

Activity 4: MCNA Roadmap View: High Level



Activity 4: MCNA Roadmap View: Detailed



Traceability

- To ensure that the elements of the MCNA roadmap meet the roadmap objectives and the roadmap is complete, traceability was performed between the elements of the roadmap and related MCNA material developed as part of this study
- Specifically, traceability was performed between the roadmap elements and the following:
  - Gap/Shortcomings (defined during the gap analysis): to ensure that roadmap elements exist to address all identified shortcomings
  - SED Recommendations: to ensure the recommended simulation, emulation and demonstration activities were addressed by roadmap elements
  - MCNA functions: to ensure the roadmap elements lead to the level of capability expected in 2015
  - Environmental Inputs/Outputs: to ensure that inputs to or outputs from MCNA development activities to specific environmental activities are associated with specific roadmap elements/activities

MCNA Roadmap Traceability Matrix

Excerpt from Traceability Matrix

ID	MCNA Roadmap Element	Traceability to Defined Gaps	Traceability to SED Recommendations	Traceability to MCNA Functions	Traceability to Envir. Inputs & Outputs
1	Refinement of Architecture, Requirements, Transition Plan	5,8,9		ALL	2, 3, 10, 11
2	Certification Process Definition/Standardization Support: Develop process for submission and review of relevant data supporting the certification of Commercial Systems/Software for AOC and ATS applications	12, 20, 22, 23, 24, 25, 26			1, 4, 6, 7
3	Certification Documentation Definition Support: Define required documentation for the defined process of certifying commercial systems for AOC and ATS applications	21			1, 4, 6, 7
4	Structured Analysis of Communication Services and RCP: Participate in RCP definition of end-to-end performance (including support for safety analysis)	1, 2, 3, 4, 26			2, 3, 5
5	IPv6 Mobility Standards & IP-based Datalink Development (includes participation in Mobile IP Standards Organizations to define an aeronautical IPv6 with appropriate security, mobility and peer-to-peer support)	6, 8, 14, 15, 16, 17, 18, 19, 25	Model and demonstrate mobility protocols and dynamic routing	Transport Data; Provide QoS; Provide Naming and Addressing; Manage Routing Policy and Mobility	13, 14

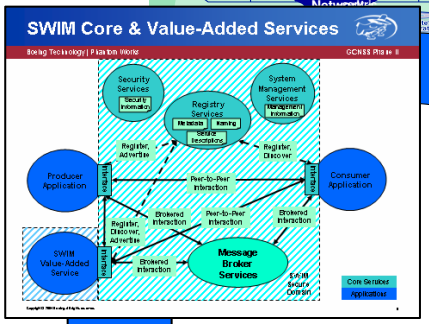
Boeing Technology
Phantom Works

Final Conclusions & Recommendations

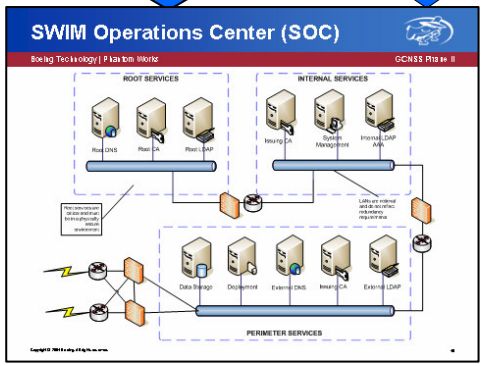
Karl Griep
MCNA Final Briefing
15 August 2005

MCNA Relationship with Past, Present & Future NASA Research Activities

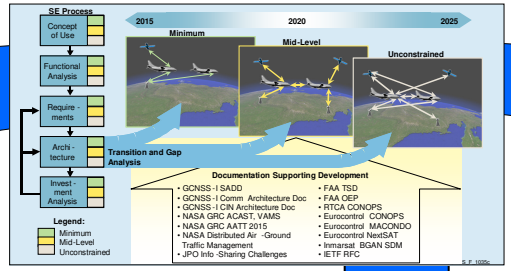
GCNSS- I
GCNSS- II



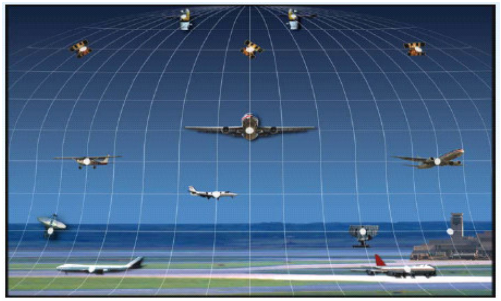
FAA
SWIM



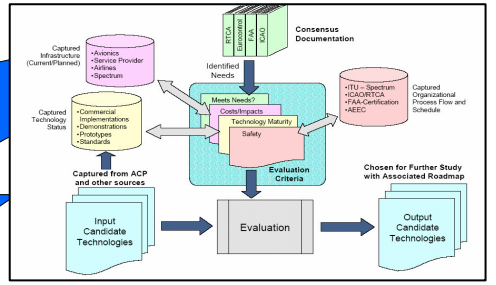
NASA/FAA
MCNA



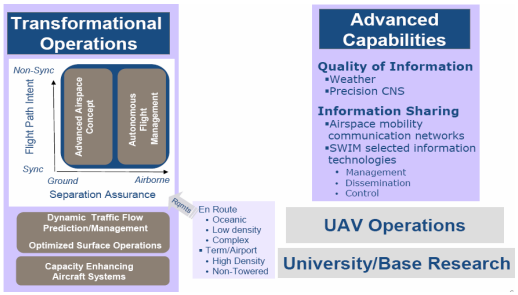
NASA SBT
2007-2015



FAA/NASA
Future Communications Study



NASA TNAS
2015-2025



What is MCNA ?

- **The aggregate of all A-G and A-A voice and data communications for CNS/ATM**
  - **Includes physical and datalink aspects**
  - **Most concerned with internetworking considerations**
- **MCNA is a Methodology for integrating disparate A-G & A-A communications links into a coherent communication networking solution**
  - **Achieving aggressive service levels using two or more individual communication systems**
  - **Seamless service coverage across airspace domains and all aircraft classes**
- **This effort has specifically focused on communication support for Network Centric Operations**

Summary of Conclusions and Recommendations

- Comparison of ATN and MCNA
- Required Communication Performance (RCP)
- Common Links for Safety of Life and Non-Safety of Life Traffic
- Certification Process Enhancements
- Initiate Near Term Deployment of IP
- MCNA as a Transformational Approach

MCNA vs. ATN

- MCNA is very similar and complementary to ATN
  - ATN network protocol selection was best at the time
  - Commercial networking selected an alternate course - IP
  - IP incorporates 15 years of continuous process improvement
    - Fueled by a thriving, multi-billion dollar IT industry
    - Much has been learned about structure networking protocols
- MCNA only proposes to extend Layers-3&4 of ATN
  - CLNP becomes IPv6 and TP4 become TCP
  - ATN upper layer protocols and applications remain unchanged
  - IP-based ATN provides “best-of-breed” protocol stack
- ICAO is already moving towards TCP/IP
  - Already recognized the merits for G-G
  - Investigating the potential for A-G

RCP

- Tightly coupled with MCNA
- MCNA must influence RCP process
  - Must assure that RCP can be met using multiple links
  - Justification through operational analysis
  - Re-evaluated requirements for multihoming and PBR
- RCP Complexity
  - More complex than RNP (wider range of applications)
  - Removing barriers to entry for new communication services
    - Decouples communications systems from the applications
- Interoperability
  - May introduce even greater barriers to entry
  - Backward compatibility must be maintained!

Common Links

- Equipage cost is a barrier to MCNA
  - Shared links maximize the benefits while sharing cost
- MCNA should enabled shared links
  - Maximize cost/benefit
  - Expedite equipage adoption
- Requires QoS assurance
  - Over-provisioning
  - Fixed allocations
  - Priority, pre-emption and precedence (PPP)
- IPv6 is the logical choice for shared A-G links
  - Airlines will not transition to ATN for AOC, AAC or APC
  - Airlines are increasingly demanding IP
    - reduce cost and increase interoperability
  - OMB mandate for IPv6 vs. IPv4

Certification

- No process to certify commercial comm. systems
  - Open ended, thus too risky for most service providers
  - Build upon RTCA DO-270
- Certification through demonstrated performance
  - Use new links for APC/AAC services but monitor to demonstrate/establish performance
  - Use monitored data to justify use of commercial service for AOC and eventually ATS services
- Application layer integrity mechanisms could allow relaxed software certification for comm. avionics
  - Only integrity failures require Level-C
  - Protected Mode (PM) – CDPLC, PM-ADS, PM-FIS
    - Note - PM provides no security just data integrity
  - DO-290, DO-296

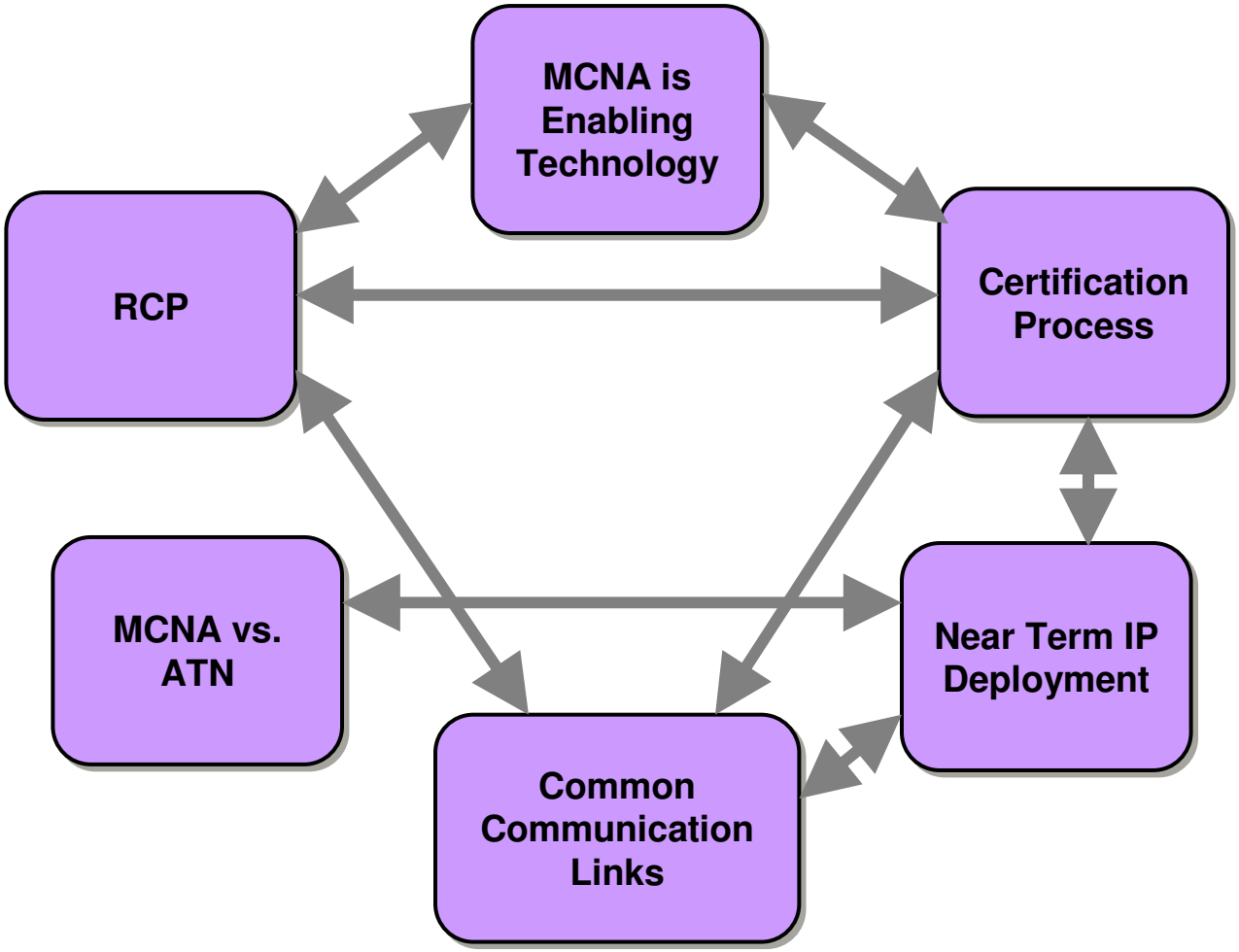
Initiate Near Term Deployment of IP

- IPv6 selected for SWIM and MCNA
- IPv6 does not support certain ATN requirements
  - Mobility with mulithoming & policy based routing
- Current and planned datalink services are based upon message transfer
- COTS IP-based message transfer services (MTS)
  - Overcome IPv6 shortcomings in the near term
  - Same technology selected for SWIM
  - Opportunity to introduce security
  - Early SWIM services to the aircraft
- Common IP link also supports APC, AAC and AOC
  - ARINC 633 – Common AOC message format (ACARS & XML)

MCNA is a Transformational Approach to A-G & A-A Communications

- Similar Investment Analysis issues as SWIM and FTI
  - Enabling technologies based on common networking infrastructure
- MCNA is not a data link technology or a FAA program
  - Design approach/methodology to extend SWIM benefits and NCO capabilities to the aircraft
  - A Network Architecture for Mobile Nodes in the NAS
- Enables certain benefits stand-alone
  - e.g. CPDLC reduction of pilot and controller workload
- Mostly enables operational enhancements in conjunction with revised procedures and new automation
  - e.g. JPDO's Agile NAS
- Up front investment to provide long-term rewards

Conclusions and Recommendation Relationships



Future Work

- **Conduct second iteration of the MCNA SoSE process**
  - **Engage stakeholders to determine highest value operational scenarios for near term deployment**
  - **Refine scenarios, communication services and communication system characterization with recent industry work**
  - **Update outputs**
- **Initiate trials using IP to understand remaining issues and develop service history**
  - **Lab experimentation for validation of protocols and architecture concepts**
  - **Progressive trials of IP for AOC, AOC (via ACARS), FANS and ATN**

Questions and Contact Information

- All deliverables will be available on the ACAST website
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  - david.c.morse2@boeing.com
- Questions: